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THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY

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TUMOURS OF THE SMALL INTESTINE (EXCLUDING THE DUODENUM).

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AND

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NEOPLASMS in the small intestine, other than the duodenum, are by no means common, and it rarely falls to the lot of any one surgeon to have the opportunity of observing more than a few instances of such tumours.

As one of the writers (C.P.G.W.) has had the exceptional experience of having had nine cases in his own practice, a record of these cases may be of some little interest. A series of illustrations of the naked eye and microscopical appearances of these tumours has been made, since we are of the opinion that the chief value of a record of rare cases is the furnishing of complete accounts of each case for future reference. We have added a brief bibliography of the ever-increasing literature on the subject in order to provide a suitable setting for our own case records, and we have quoted accounts of some of the rarer recorded cases, when such accounts provide a graphic illustration of the pathology and symptomatology of these tumours.

The tumours are naturally best classified on a histological basis, but, as would be expected, the clinical picture produced by a tumour is more closely related to the naked eye characteristics of the growth. For these reasons the symptoms and signs produced by these tumours

are considered together, in one section, where the modification in the clinical history produced by the different naked eye forms of the tumours is discussed.

The tumours naturally fall into the two main groups, innocent and malignant; some of the tumours, however, present features which render their classification difficult, even under these two main heads.

The argentaffin or carcinoid tumours were regarded as innocent by some of the older writers, but more modern investigation has definitely demonstrated the malignancy of these growths. On the other hand, the endometriomata are a group of innocent tumours which resemble malignant tumours in their mode of dissemination.

THE INNOCENT TUMOURS.

The main varieties of innocent tumours are included in the following: Fibro-myomata, fibromata, neuro-fibromata, lipomata, hæmangiomata, endometriomata, adenomata.

Benign tumours apparently are less common than malignant growths. It is probable, however, that were routine *post mortem* examination of the small intestine the rule rather than the exception, many more examples of benign tumours would be discovered, as these growths not uncommonly give rise to few or no symptoms during life.

E. L. King[1] collected records of 118 cases, and his list serves to show the relative frequency of these tumours:

Fibro-myomata	45 cases	
Lipomata	29 cases	
Adenomata	17 cases	
Fibromata	14 cases	
Fibro-myxomata	3 cases	
Angiomata	3 cases	
Neuro-fibromata	3 cases	
Teratoblastomata	2 cases	
Rhabdomyomata	1 case	(probably malignant)
Fibro-adenomata	1 case	
	118 cases	

The Fibro-Myomata.

The fibro-myomata are the commonest innocent tumours of the small intestine. The use of the name "fibro-myoma" is open to criticism. According to some writers the fibrous tissue is to be regarded as the stroma of the myomatous tissue, and the title they would use would be the "myomata."

The intimate admixture of fibrous and myomatous tissue found in these tumours closely resembles the appearances of a fibro-myoma of the uterus, and is quite unlike the arrangement of the fibrous tissue stroma, disposed in definite strands, as is seen in such tumours as the chondromata. We prefer the term fibro-myoma as conveying a more accurate picture of the histological appearances of these tumours.

FIGURE I.

The relative proportion of the fibrous tissue to the plain muscle fibres varies greatly in different cases; some are almost pure myomata, with little admixture of fibrous tissue, and others, on the other hand, are almost pure fibromata.

In Case XVII (quoted by E. L. King) the tumour was calcified in the centre. In Case XLIII (King) a portion of the tumour had undergone sarcomatous change. These tumours are single, are in the form of rounded masses and vary in size from a small nut to a large mass weighing some 5·4 kilograms (twelve pounds).

They may be pedunculated or sessile, and are most often submucous in situation, but may be subserous. Of the two possible sites of origin, the muscular coats of the bowel and the *muscularis mucosæ*, the former is the more probable.

A fibro-myoma is more commonly met with in the ileum than in the jejunum and duodenum. E. L. King's small intestine fibro-myomata were distributed as follows:

Ileum	12
Jejunum	5
Duodenum	3
Small intestine	2 (exact site not stated)

The Fibromata.

The fibromata are very rare tumours. King collected four cases only of pure fibromata and three cases of fibro-myomata.

We here record a case of fibroma of the jejunum. An interesting feature of the fibroma is well shown in our case. There is no line of demarcation between the mucous membrane and the tumour, the fibroma extending right up to the mucous membrane and even encloses some of the glands of Lieberkühn in its substance (see Figure IV).

This is a feature common to many fibromata, a good example being the desmoid tumours of the abdominal muscles which commonly infiltrate the muscle fibres.

Another point worthy of comment is the presence, in the substance of the tumour, of numerous blood vessels which possess well marked plain muscle coats. In some portions of the section a tangential slice of the vessel wall may appear as a clump of plain muscle fibres; these are easily distinguished from the muscle fibres of a fibro-myoma in which the fibrous tissue element and the muscle fibres are intimately mixed, the latter not being disposed in discrete clumps. The fibromata occur either as submucous or subserous tumours, and may occasionally be multiple (Case V, King).

Case I.—Fibroma of the Jejunum.

R.C., aged fifty-two years, was admitted to King's College Hospital on December 8, 1928, complaining of abdominal pain, from which she had suffered since August, 1928. The pain was intermittent, lasting from one to five minutes, and was associated with nausea. Her appetite had decreased, but her bowels were opened daily without aperients.

Towards the end of September, 1928, the pain had become more severe, causing her to double up and to cry out during the attacks. About this time she began to vomit a large amount of yellow material, the vomiting usually occurring twice a week. Vomiting did not relieve the pain. She limited herself to a fluid diet, and now suffered from constipation, but with the help of aperients had no difficulty in obtaining a small daily motion. She began to lose weight rapidly.

FIGURE II.

About the middle of November, 1928, she attended King's College Hospital as an out-patient, and was given a barium meal and skiagrams were taken. The radiologist reported "chronic small intestine obstruction due to adhesions in the region of the spleen." The patient became weaker and, as the pain was increasing, arrangements were made for her admission as an in-patient.

On admission on December 8, 1928, she stated that she had had severe abdominal pain on the morning before admission, but was now easier. Her bowels had been opened the previous morning (December 7, 1928), but, although her bowels had been opened daily up to that date, the motions were very small in amount.

She had last vomited on December 5, 1928, and had been greatly troubled with flatulence, which "passed upwards." She had an anxious facial expression.

Her temperature was 36·4° C. (97·6° F.), her pulse rate 100 and her respiratory rate 20. The tongue was flabby and furred. Abdominal distension, especially around the umbilicus, was well marked. Visible peristalsis was noted. The abdominal wall moved freely on respiration, and on palpation there was no tenderness or rigidity. On rectal examination the rectum was found to be empty, and nothing abnormal was felt.

Operation Notes.—A right paramedian incision was made. An intussusception of the upper end of the jejunum, which could not be reduced owing to the œdematous state of the intestinal wall, was found; 90 centimetres (three feet) of intestine were resected, and a lateral anastomosis was performed after closure of the two ends. Recovery was uneventful, the patient leaving hospital on December 29.

The X Ray Photograph (Figures II and III).—The photograph shows a greatly distended loop of small intestine filled with barium, with a thin stream of barium trickling through a tortuous canal at the distal end of the loop. The photograph taken seven hours after the meal shows that, in spite of a very marked obstruction in the small intestine where the lumen is no larger than a crow quill, the barium meal has reached not only the caecum, but has progressed as far as the splenic flexure.

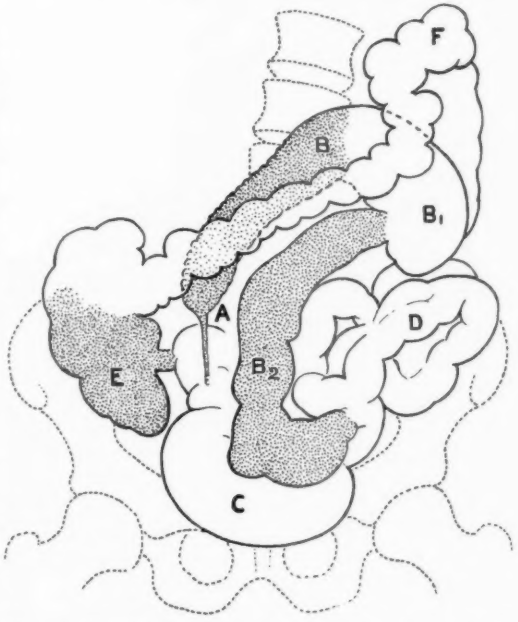

FIGURE III. Diagrammatic representation of Figure II. A = site of the obstruction; B = loop immediately above showing active peristaltic waves; B_1 = gas in loop; B_2 = barium-filled dilated loop; C = dilated gas-filled loop; D = normal small intestine with very little barium; E = caecum; F = splenic flexure.

The Specimen (Figure I).—The specimen shows an acutely inflamed loop of jejunum, the peritoneal coat being bright red and roughened with shreds of lymph. The peritoneum of the mesentery shows similar changes. The bowel has been opened and an oval polypoid tumour the size of a golf ball is seen projecting into its lumen. The cut surface of the tumour is yellowish-white, and is covered by smooth mucous membrane, which, owing to acute congestion, is bright red in colour.

Microscopical Section (Figure IV).—The tumour is composed of finely fibrillated fibrous tissue and connective tissue cells whose nuclei are oval or triangular. The tumour is supplied with numerous blood vessels with well marked plain muscle coats. Tangential shavings of the vessel walls are seen as clumps of plain muscle fibres. The mucous membrane covering the tumour is lined by

cells whose protoplasm stains more deeply than the cells of the adjoining normal mucous membrane; there are only a few goblet cells. The crypts of Lieberkühn are remarkably elongated and extend into the tissue of the tumour, which extends as far as the mucous membrane.

Comments on the Case.—The four months' history of intestinal colic is characteristic, and is due to exaggerated peristaltic waves set up by

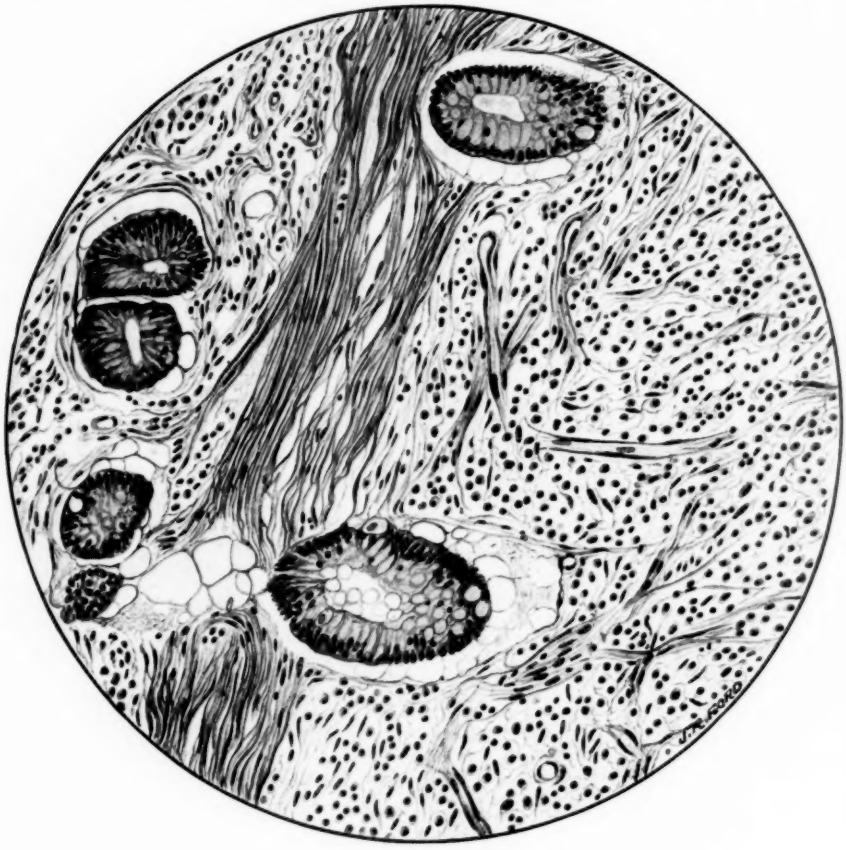

FIGURE IV.

the tumour. The yellow vomit distinguishes it from the vomit of a case of pyloric obstruction.

The skiagram is diagnostic of a small intestine obstruction, and the facility with which the contents pass through the narrowed lumen is also characteristic of a small intestine obstruction.

The normal small intestine transmits the barium meal so rapidly that the presence of a dilated, distended loop of small bowel is diagnostic of an obstruction. The loop does not show the characteristic numerous concertina-like indentations produced by peristalsis in the normal small intestine.

The Neuro-fibromata.

Three cases are recorded of pure fibromata of the small intestine found in association with generalized neuro-fibromatosis. These can scarcely be regarded as cases of coincidence, and it is more rational to regard them as neuro-fibromata, originating in the nerve plexuses of the intestinal wall. Owing to their rarity, a brief account of these cases, quoted from E. L. King's article, is here appended.

The first case is that of Leriche (*Lyon Chirurgical*, 1911, Volume VI, page 70). A male, aged forty-five years, had a neuro-fibroma in the pylorus, and many small pure fibromata in the intestines with no trace of nerve tissue in them. The pyloric tumour had undergone a sarcomatous change. This patient had generalized neuro-fibromatosis and pulmonary tuberculosis. Operation consisted of gastro-enterostomy and pylorectomy. Death occurred two weeks later from purulent pleurisy.

The second case is that of Marie and Couvelaire (*Nouvelles Iconographique de la Salpêtrière*, 1900, Volume XIII, page 26). The patient had a generalized neuro-fibromatosis. No intestinal symptoms were present during life. At autopsy two fibromata in the duodenum and eight in the rest of the small intestine were discovered.

The third case is that of Branca (*Bulletins de la Société Anatomique de Paris*, 1897, Volume LXXVII, page 166). The patient had a generalized neuro-fibromatosis. The patient died of pulmonary tuberculosis and at autopsy many fibromata of the intestine were discovered.

The Lipomata.

The lipomata occur as pedunculated or sessile, submucous or sub-peritoneal tumours. The pedunculated submucous growth is the variety most often met with. They rarely reach a larger size than a walnut, and are occasionally multiple. In some cases they may be associated with gastric or large intestine lipomata. Lipomata of the small intestine are less rare than those of the large intestine. They occur in both sexes, and usually produce symptoms between the ages of thirty and fifty.

The Hæmangiomata.

Hæmangiomata are cavernous hæmangiomata which may produce no symptoms or signs, or may give rise to so severe a hæmorrhage as to lead to death. They have been known to give rise to intussusception.

Owing to their rarity, a few illustrative cases are quoted. MacCullum[2] collected four recorded cases, and added one which came under his personal observation.

The first case quoted is that of Labailbene, 1872. A man, aged sixty-four years, passed blood in his stools one morning. This lasted for several days. A month later the hæmorrhage in the stools was repeated, and he vomited black coagulated blood. Physical examination revealed no abnormality, and a duodenal ulcer was diagnosed. A few days later he had another extensive hæmorrhage from the bowel and died. At the subsequent *post mortem* examination the intestines were found to be full of blood, a tumour the size of an almond, covered by mucosa which

had ulcerated at one part, was found in the duodenum just above the biliary papilla. Microscopically the tumour was composed of dilated capillaries, with numerous sacculations in their walls.

The second case is that of Paci, 1882. A woman had a short history of intestinal obstructions which subsided, and the patient passed *per rectum* a mass of tissue which was recognized as a cavernous hæmangioma covered by normal intestinal mucosa.

The third and fourth cases and MacCullum's case were similar and were all discovered in the course of routine *post mortem* examination. The tumours were multiple and occurred throughout the small intestine. Kortzebom[3] describes a cavernous hæmangioma of the ileum in a patient on whom he operated. The tumour had produced attacks of intestinal hæmorrhage for seven years, and there had been occasional attacks of colicky pain. The patient was operated upon and a tumour the size of an apricot was found in the ileum, 75 centimetres from the ileo-caecal valve. The affected portion of ileum was resected, and the patient made an uneventful recovery.

Kortzebom refers to the only two other cases, recorded in the literature on the subject, in which operation was performed. Rodelius operated on a patient with intestinal obstruction produced by a hæmangioma of the small intestine, and Landors discovered a hæmangioma of the small intestine while doing an appendicectomy, and excised the tumour to prevent such future complications as intestinal obstruction or hæmorrhage.

The Endometriomata.

The endometriomata are a group of rare tumours which present several interesting features of pathological interest. The tumour is composed of tubular glandular spaces lined by short columnar epithelium lying in a stroma of short spindle cells. Some of the tubular spaces are dilated and some contain blood. The microscopical structure resembles that of the uterine endometrium, and the presence of blood in the tubular space indicates the retention of the function of menstruation by these tumours. They are found in the pouch of Douglas or in the walls of the pelvic viscera, affecting the terminal ends of the ileum, the sigmoid, rectum and the appendix. These tumours are, as would be expected, limited to the female sex, and are nearly always associated with the hæmorrhagic, so-called chocolate cysts of the ovary, which have perforated the surface of the ovary.

Sampson[4] points out that although these cysts of the ovary are generally two to four centimetres in diameter, they are sometimes so small and inconspicuous as to be easily missed, not only at operation, but even in the course of a routine pathological examination of an ovary excised at operation.

These cysts have the same microscopical structure as the endometrium of the uterus, and Blair Bell has shown that the blood in them is devoid of fibrin ferment, thus resembling menstrual blood.

Sampson's view of the genesis of these tumours gives the best explanation of their behaviour. He regards the endometriomata as implantation tumours from hæmorrhagic cysts of the ovary. The ovary

in its turn has received an endometrial implant before disseminating it into the peritoneal cavity. In support of this view is the fact that the chocolate cysts of the ovary are always found in the postero-inferior surface of this organ, which is the surface lying close to the ostium of the Fallopian tube.

The ileal tumours are found on the peritoneal surface of the gut, and may invade the muscular walls deeply. The peritoneal surface is puckered at the site of the tumour, and the intestine may be adherent at this point to the ovary or uterus, the adhesion being composed of endometrial tissue.

Sampson divides the intestinal endometriomata into three classes: (i) Surface or superficial implantation growths; (ii) "pocketed implantations" between adherent peritoneal folds, or between adherent viscera, the adhesions being composed of endometrial tissue; (iii) implants which have invaded deeply the muscular coats of the bowel.

The endometriomata resemble malignant growths in their mode of dissemination by transcœlomic implantation and in their invasion of the muscular coats of the bowel. The histological structure is, however, that of the normal endometrium of the uterus; there is no evidence of abnormal or disorderly growth, either in the arrangement of the cells or in the mode of cell division; and the invasion of the muscular coat of the bowel is by displacement of the muscular layers and not by an infiltration of the normal tissue.

These tumours are found in women between the ages of thirty and the menopause. They are generally married women who are nulliparous. The patient is operated on for abdominal pain and severe dysmenorrhœa.

Illustrative Cases Quoted from the Literature.

The following cases are quoted from the literature on the subject.

Sampson (Case III) reported a nulliparous woman of forty-two years, who had been married fourteen years, and who complained of profuse painful menorrhagia of two years' duration. At the operation multiple myomata of the uterus were found. The right ovary had a chocolate cyst. The ileum, ten centimetres (four inches) from the ileo-caecal valve, had a hard indurated lump, and the appendix had a similar lump; these lumps were thought to be malignant nodules. The ileum was resected, and end-to-end anastomosis was done by Murphy's button. The appendix was excised, and the right Fallopian tube and ovary were excised.

On microscopical examination the hæmorrhagic cyst of the ovary was seen to be an endometrioma and the tumours of the appendix and ileum were also endometriomata. The ileal tumour had invaded the muscular walls.

Sampson's Case XII was that of a nulliparous female of fifty-five years who had been married five years, and who complained of severe dysmenorrhœa, backache and sensation of pressure in the rectum. She had always suffered from dysmenorrhœa, and four years ago an operation was performed for acute abdominal pain, when both Fallopian tubes, the left ovary and the appendix were excised. On examination *per vaginam* the utero-sacral ligaments were felt to be nodular and thickened. A pre-operative diagnosis was made of an endometrioma involving the pouch of Douglas and the utero-sacral ligaments. At the operation the sigmoid was found adherent to the left uterine cervix, and a loop of small intestine was adherent to the posterior uterine wall. The uterus and remaining ovary were excised after the adhesions had been separated. Microscopical examination of

the specimens revealed endometriomata invading the posterior uterine wall and the utero-sacral ligaments.

Clara Stewart[5] recorded the case of a nulliparous woman, aged forty-four years, who had been married for twelve years, and who complained of pain and sickness of two years' duration, worse during the last three months. At first the pain occurred after food, but lately it had become continuous. It was colicky in character and infraumbilical in position. Sickness was worse during the menses, and was aggravated by solid food. She had lost weight during the last two years. At the operation a volvulus of the ileum, which was supposed to be due to a cicatricial ulcer, was found. There were no adhesions to the uterus. One foot of the ileum, the caecum, the ascending colon and part of the transverse colon were excised. Examination of the specimen showed that 7·5 centimetres (three inches) above the ileo-caecal valve there was a tumour projecting into the lumen of the bowel involving the peritoneal and muscular coats, but not the mucosa, which was infiltrated by the tumour. A dense adhesion bound the tumour to the distal third of the appendix. The bowel above was dilated and hypertrophied, while the bowel below was small and contracted. The twisted loop was matted with old adhesions. Microscopical examination showed the tumour to be an endometrioma.

Mouat[6] operated on a nulliparous woman, aged thirty-six years, who complained of lower abdominal pain and severe dysmenorrhœa. At the operation a tumour of the ileum was found, and the affected loop was resected. Microscopical examination showed the tumour to be an endometrioma.

Adenomata.

There are two distinct varieties of adenomata, the multiple adenomata, designated *polyposis intestini*, or glandular hyperplasia of the mucous membrane (Saint[8]), and the isolated adenomata, which are single or few in number.

In *polyposis intestini* the mucous membrane is studded with myriads of small sessile or pedunculated tumours, generally one millimetre in diameter and situated mainly on the crests of the *valvulæ conniventes*.

Illustrative Recorded Cases.

The following are illustrative cases recorded in the literature.

Kanthack and Furnival[7] report a girl, aged thirteen years, who died from septicæmia, having had no intestinal symptoms. At the *post mortem* examination the *valvulæ conniventes* of the whole of the duodenum and jejunum were studded and fringed with small short polypi, having short, thick pedicles and a velvety appearance, due to the intestinal villi on their surfaces. A few polypi were seen between the *valvulæ conniventes* and a small number were found in the ileum. There were three small polypi in the sigmoid. On microscopical examination the polypi were found to be composed of mucous membrane having normal intestinal villi, *muscularis mucosæ* and submucous tissues.

Allchin and Hebb[9] report that at a *post mortem* examination the entire mucosa of the small intestine, especially the duodenum and jejunum, was found to be studded with myriads of white flocculi, giving the mucous membrane a shaggy, coarsely villous appearance. Peyer's patches were atrophied and the mesenteric glands enlarged. On microscopical examination the polypi were seen to be composed of villi with distended lacteals in their centres.

These writers concluded that the condition was due to lymphatic obstruction, a view Kanthack and Furnival were unable to corroborate from their own case recorded two years later.

Clinical Features and Relationship to Carcinomata.

The adenomata which are single or few in number, are generally sessile or provided with a short thick pedicle. They may be associated with similar polypi in the large intestine. The tumour is composed of glandular acini and a stroma of connective tissue. The cells may stain more deeply than the cells of the surrounding mucous membrane, and the mucin-containing cells are fewer in number, but the cells are columnar, regular in arrangement, one layer thick, and there are no mitotic figures or differences in the size of the cells. The relation of the adenomata to the carcinomatous tumours is of considerable pathological and clinical interest. Cuthbert Duke's convincing paper clearly demonstrates the precancerous nature of *polyposis intestini* in the large intestine, 21 out of 50 patients affected by *polyposis intestini* dying of carcinoma of the bowel.

In the large intestine the condition is hereditary and familial, the tendency to *polyposis intestini* being a Mendelian dominant.

The number of cases of *polyposis intestini* of the small intestine is too small to enable similar conclusions to be drawn in regard to them, nor are we aware of such a case in which a carcinoma of the small bowel had been noted. The adenomata which are single or few in number, are, however, sometimes found with a carcinomatous change in some part of the tumour.

Judd[21] divides jejunal carcinomata into two classes, "ring carcinomata" and "degenerate polypi" which may be multiple. Similarly he considers that the polypoid type of ileal carcinoma arises in a degenerate polypus. He sums up the position by saying: "A number of carcinomas of the small intestine arise in polyps." He uses the term "polyp" to designate an adenomatous polypus.

Case II: Sessile Adenomata of the Jejunum.

Edith T., aged fifty-eight years, had enjoyed good health till the age of fifty-six, when she began to suffer from repeated attacks of epigastric pain accompanied by vomiting and diarrhœa. The only treatment that gave her relief was a mixture containing bismuth carbonate to which a few drops of tincture of opium were added.

The attacks came on at frequent intervals, and the patient lost nearly 12·6 kilograms (two stone) in weight in two years. Repeated examination of the abdomen by her local doctor failed to reveal any signs of disease. She was admitted to hospital in 1926 after a very severe attack of vomiting and diarrhœa. The stools contained quite a large amount of blood.

On examination the patient was seen to be very anæmic and exhausted. Hourly feeds of citrated milk and glucose saline were given *per rectum*. The general condition improved. The next day visible peristalsis was easily seen on abdominal inspection. No abdominal tumour was palpable. Under gas and oxygen anæsthesia the abdominal cavity was explored through a right paramedian incision. Blood stained fluid escaped on opening the peritoneal cavity. A large jejunal intussusception was seen and delivered out of the wound. It was situated 240 centimetres (eight feet) from the duodeno-jejunal angle. It was easily reduced, and a firm tumour was felt inside the bowel. The bowel was opened by an incision along the antimesenteric border, and a sessile tumour was seen attached to the wall a little to one side of the mesenteric attachment. There was no infiltration at the

base of the tumour. As the appearance of the tumour did not suggest malignancy, the tumour was excised with a margin of healthy tissue. The intestinal wall was repaired by suture. The patient made an uninterrupted recovery, leaving the hospital sixteen days after the operation.

In 1928 the patient was in perfect health, and had gained 15·75 kilograms (two and a half stone) in weight.

The specimen (Figure V) shows a sessile tumour, the size of a large coat button. Its surface is convoluted and merges into the surrounding mucous membrane. On microscopical examination the tumour was found to be a typical adenoma. The glandular acini were lined by columnar cells which stained rather more deeply than the cells of the normal mucous membrane.

THE SARCOMATA.

The sarcomata are rarer than the carcinomata. De Noyelles[15] estimates the relative frequency of carcinomata to sarcomata as 20:1. Smoler (quoted by Goldstein) in 13,036 autopsies made at Prague during a period of fifteen years, found only thirteen intestinal sarcomata, all lympho-sarcomata, of which ten were in the small intestine.

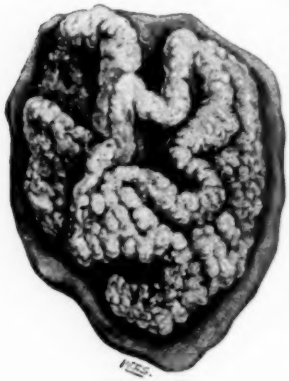

FIGURE V.

Kemp (quoted by Goldstein) refers to the statistics of the Vienna General Hospital between 1882 and 1893, which contained records of 274 autopsies on sarcoma cases, of which three only were intestinal, one was ileal, one caecal and one rectal.

Müller (quoted by Goldstein) in 102 autopsies made at Berne, found one intestinal sarcoma only, and this occurred in the ileum. In 1894 Baltzer (quoted by Goldstein) could collect 14 recorded cases only of sarcoma of the small intestine. Libman (quoted by Speese) in 1900 collected 59 cases, and Lecene (Speese) in 1904 collected 89 cases. Corner and Fairbank in 1905 collected 65 cases of sarcoma of the small intestine and 20 cases of sarcoma of the ileo-caecal region. Speese in 1914 collected 101 cases, while Goldstein in 1921 collected 130 cases.

Goldstein has given one of the best abstracts of the literature on the subject in his paper.

The relative frequency of the carcinomata to the sarcomata is illustrated by the following statistics.

Nothingel (quoted by Speese) in a series of 2,124 autopsies on cases of carcinomata, found 243 cases of intestinal cancer, while in 248 autopsies on sarcoma cases there were only three intestinal sarcomata. Waring, in a review of the cases of malignant disease treated at Saint Bartholomew's Hospital during the twenty years period 1900-1919, records only 14 cases of carcinoma of the jejunum and ileum and nine cases of sarcoma of the same region.

Sex.—Males are apparently more liable to sarcoma of the small intestine than females. Corner and Fairbank state that more than half their cases occurred in patient between the ages of twenty and forty years. The oldest was aged seventy, and the youngest was a new-born infant (Stern, quoted by Speese). The series was arranged as follows:

0 to 10 years	7 cases
10 to 20 years	7 cases
20 to 30 years	16 cases
30 to 40 years	19 cases
40 to 50 years	10 cases
50 to 70 years	4 cases

Site.—The ileum is the commonest site of the disease. The distribution of Corner and Fairbank's cases was as follows:

Œsophagus			14 cases
Stomach			58 cases
Small intestine	Duodenal	8	64 cases
	Jejunal	19	
	Ileal	28	
	Exact site not stated	9	
Ileo-caecal			20 cases
Large intestine			11 cases
Rectum			7 cases
Total			174 cases

Speese in his series of 101 cases, found details of the exact site in the small intestine given in 53 cases only, distributed as follows:

Duodenal and jejunal	3 cases
Jejunal	12 cases
Jejunal and ileal	2 cases
Ileal	32 cases
Entire intestinal tract	4 cases
Total	53 cases

Libman, quoted by Goldstein, gives the following series:

Duodenum	15 cases
Jejunal and ileal	18 cases
Ileal	14 cases
Entire intestinal tract	3 cases

Krugerz Boas, quoted by De Noyelles, compared the frequency of small intestine sarcomata with those in the large intestine in the following series:

Small intestine	16 cases
Large intestine	6 cases
Rectum	16 cases

Bottomley, quoted by Goldstein, states that 65% of intestinal sarcomata occur in the small intestine.

Morbid Anatomy.

The classification suggested by Moir and Walker describes the naked-eye appearance of these tumours in a few words:

(*a*) Polypoidal growths projecting into the lumen of the bowel.

(*b*) An extensive tubular or cuff infiltration of the bowel wall.

(*c*) A large pedunculated mass growing on the peritoneal surface of the bowel.

Hammock, quoted by Goldstein, points out that the cuff infiltration of the bowel wall is the commonest type of tumour, while the polypoidal growth projecting into the lumen of the bowel is the next commonest type. It is unusual for the serosa to be involved by the growth. Ulceration is common and perforation occasional.

The occurrence of ulceration in over half the cases and the rarity of cicatricial contracture contrast with the stenosing type of carcinomatous growths.

In some cases the growth shows extensive infiltration with no ulceration. The lumen of the bowel is not uncommonly dilated at the site of the growth. The mesenteric lymphatic glands may be enlarged, and in a few cases the pressure of the enlarged lymphatic glands produced acute intestinal obstruction (Rankin[18]).

Microscopical Anatomy.

The commonest type of growth is a round cell sarcoma. Many of the cases reported as round cell sarcoma may have been cases of lympho-sarcoma, since the histological differentiation of these two types of growth is not always easy.

Corner and Fairbank state that the growth arises most frequently in the submucous tissue. Corner and Fairbank's 45 cases were distributed as follows:

Round cell sarcoma	21 cases
Lympho-sarcoma	14 cases
Spindle cell sarcoma	7 cases
Myosarcoma	2 cases
Primary melanotic sarcoma	1 case

Speese gives the following list:

Round cell sarcoma	43 cases
Lympho-sarcoma	34 cases
Spindle cell sarcoma	13 cases
Fibro-sarcoma	3 cases
Myxo-sarcoma	2 cases
Myosarcoma	1 case
Mixed cell sarcoma	1 case

A rare form of small intestine tumour is the plasmacytoma, a growth composed of plasma cells. Four examples only of these growths have been recorded, and doubt has been expressed as to whether or no they are really tumours at all. It may be noted, however, that tumours

composed of plasma cells form one of the varieties of the growths known as multiple myelomata of bone.

The following is a recorded case of plasmacytoma:

A male, aged twenty-four years, complained of colicky abdominal pains and had signs of acute intestinal obstruction. His first attack had occurred four months previously. He had a history of dyspeptic symptoms, with alternating constipation and diarrhœa. He had no fever. At the operation a tumour was found protruding into and filling half the lumen of the small intestine. Fifteen centimetres of intestine were resected. The tumour was found to arise from the connective tissue stroma of the mucosa and submucosa, and involved the inner muscle layers to some extent. Microscopically the tumour was a plasmacytoma. This patient made an uneventful recovery and was alive and well three years later.

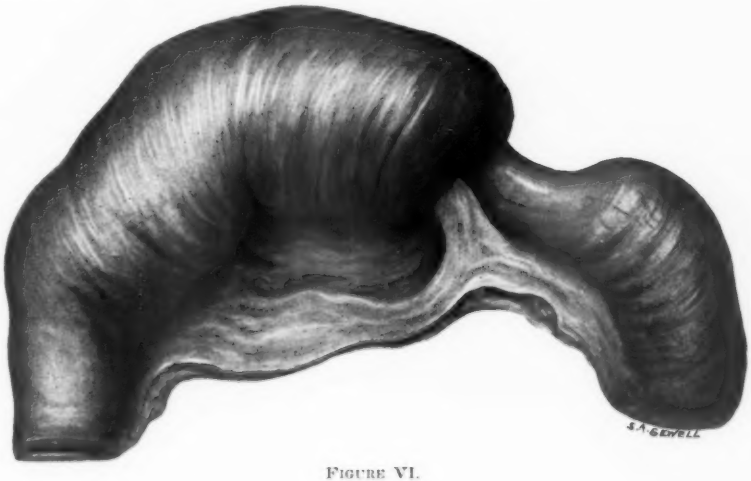

FIGURE VI.

Case III.—Fibro-sarcoma of the Ileum.

Mrs. Charles L., aged twenty-five years, had always enjoyed good health, and played tennis and golf regularly. She was sitting one day, in front of the fire, when she was suddenly seized with violent abdominal pain, and went to bed. She had no vomiting, the pain slowly subsided, but returned the following day. Her bowels were moved and there was no blood in the stools. On examination nothing abnormal was detected in the abdomen and a rectal examination revealed no abnormality. Two days later the pain became worse and the abdomen was distended. She was admitted to King's College Hospital, where, on examination under an anæsthetic, a movable hard lump was palpated, and visible peristalsis was seen.

The abdomen was explored through a mid-line incision. There was a little free fluid in the abdomen and on exploration a large dark red mass was seen in the lower part of the ileum, and proved to be a large enteric intussusception. This was for the most part easily reducible, except for the last portion, through which a definite lump could be felt in the lumen of the bowel. The gut was resected, and an end-to-end anastomosis effected. This patient made an uninterrupted recovery, and was known to be alive and well six years after the operation.

The Specimen (Figure VI).—This shows the loop of bowel excised at the operation. The proximal portion of the intussusception is still unreduced. The peritoneal surface of the bowel is red, and the entering layer of the bowel is narrowed from compression.

Figure VII shows a transverse section of the intestine. Projecting into the lumen is a sessile growth covered by mucous membrane. The cut section of the growth is yellowish-white. The peritoneal coat is not involved by the growth. The tumour is composed of short spindle cells, whose nuclei show numerous mitotic figures. There are many bundles of fibrous tissue amongst these cells. The tumour is supplied with numerous blood vessels, which are very well formed and show well-marked plain muscle coats. The tumour has infiltrated and destroyed all the coats of the intestine, and at the edge of the growth the muscle coat of the bowel, the *muscularis mucosæ*, and the mucous membrane can be traced for a short distance into the substance of the tumour.

Comments.—The short history of two days is noteworthy, and the absence of blood in the stools is not uncommon in cases of intussusception occurring in adults.

FIGURE VII.

Case IV.—Fibro-sarcoma of the Jejunum.

Frank H., aged forty-two years, a labourer, had suffered from "indigestion" for the last ten years. During the last six months he had lost weight. He was sent into King's College Hospital by his local doctor, who had found a lump in his abdomen. The "indigestion" was most marked shortly after meals, and although the patient frequently experienced nausea, he had never vomited.

On admission he was found to be suffering from abdominal colic, and diarrhœa now replaced the constipation from which he had been previously troubled. A very hard, irregular tumour was palpated in the umbilical region. It was freely movable both from side to side and upwards and downwards. Palpation gave the patient a feeling of nausea. The liver was not palpable, and there was no evidence of ascites. The abdomen was explored through a right paramedian incision. A large, hard, fibrous growth was seen growing from the antimesenteric portion of a loop of jejunum 150 centimetres (five feet) distal to the duodeno-jejunal flexure. A wide resection of the affected loop of bowel was performed, and an end-to-end anastomosis effected. This patient made an uninterrupted recovery.

Figure VIII shows a dilated loop of jejunum with a large tumour growing from the antimesenteric border of the bowel. The tumour is composed of lobules of tumour substance held together by septa of fibrous tissue. On microscopical section the growth was found to be a spindle cell sarcoma.

Comment.—This case is an example of the uncommon subperitoneal type of sarcoma.

Case V.—Spindle Cell Sarcoma of the Jejunum.

Mrs. Ellen R., aged forty-three years, had always enjoyed good health until June 28, 1930, when she felt sick and thought it was the commencement of a bilious attack. She had never suffered from indigestion, but had an occasional

"bilious attack," which she thought was due to the fact that she had allowed herself to become constipated. After suffering from nausea for three hours, she vomited large quantities of mucus, and this was followed by severe pain across the epigastrium. The pain was accompanied by a desire to defæcate, and the patient passed what she thought was a very watery motion, but she noticed that it consisted mostly of blood. Ten minutes later she passed a large amount of blood *per rectum* which she estimated as quite a quart. She went to bed, and during the

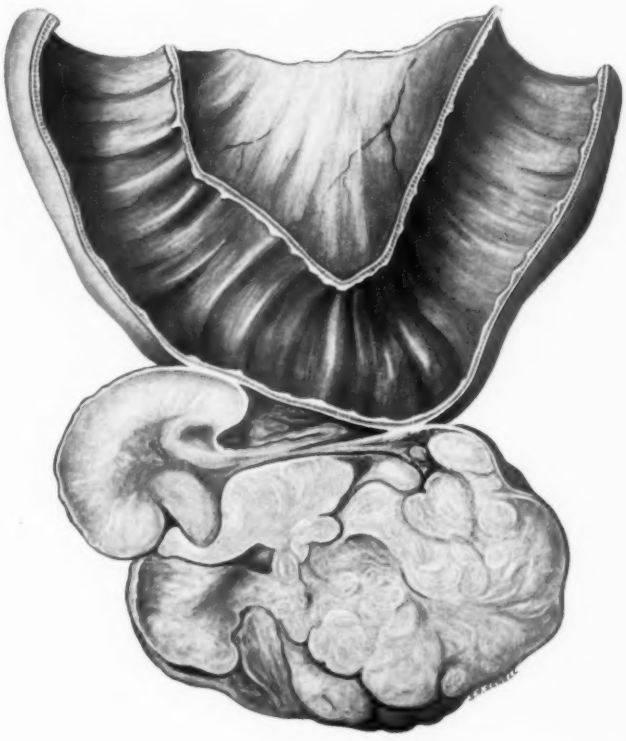

FIGURE VIII.

night passed three more motions consisting mostly of blood. She felt faint the next morning, and sent for her doctor, who gave her some medicine. About 10 a.m. she vomited blood and mucus, and also had frequent bloody stools. She was transferred to King's College Hospital within twenty-four hours of the onset of her symptoms. On admission, the pallor of the patient was noticeable, but it was not of such a degree as to suggest a severe hæmorrhage. Her pulse was rapid and running, being 146 beats to the minute. The cardiac dulness was within normal limits, and the heart sounds were faint and tic-tac in character. The abdomen was quite soft and there was no distension or tenderness. Rectal and vaginal examination revealed no abnormality.

The blood count was:

Red blood corpuscles, per cubic millimetre ..	1,280,000
Hæmoglobin value	19%
Colour index	0·76

Slight anisocytosis was present.

The patient was put on citrated milk, 120 cubic centimetres (four fluid ounces), every two hours, no other food being allowed. She continued to have

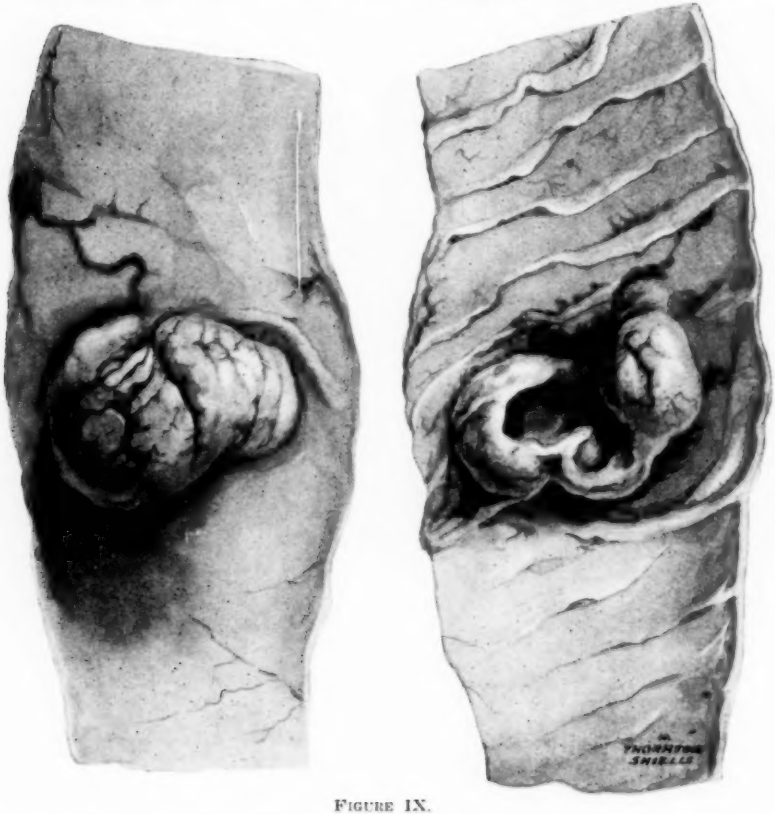

FIGURE IX.

bloody motions. Morphine 0·01 gramme (one-sixth of a grain) was given at night. The patient's blood was tested and found to belong to Group IV.

On July 4 the blood count was:

Red blood corpuscles, per cubic millimetre ..	1,060,000
Platelets, per cubic millimetre	100,000

On July 8 the blood count was:

Red blood corpuscles, per cubic millimetre ..	708,000
Hæmoglobin value	10%
Colour index	0·71

The patient remained in the same condition, her abdomen being soft and not distended. On July 8 a blood transfusion was done, 250 cubic centimetres being given. This was followed by a rigor, and death occurred soon afterwards. At the autopsy there was no blood in the bowel. A firm nodular growth, the size of a plum, on the antimesenteric border of the jejunum, projected from the peritoneal and mucous membrane surfaces of the gut. The growth was situated in

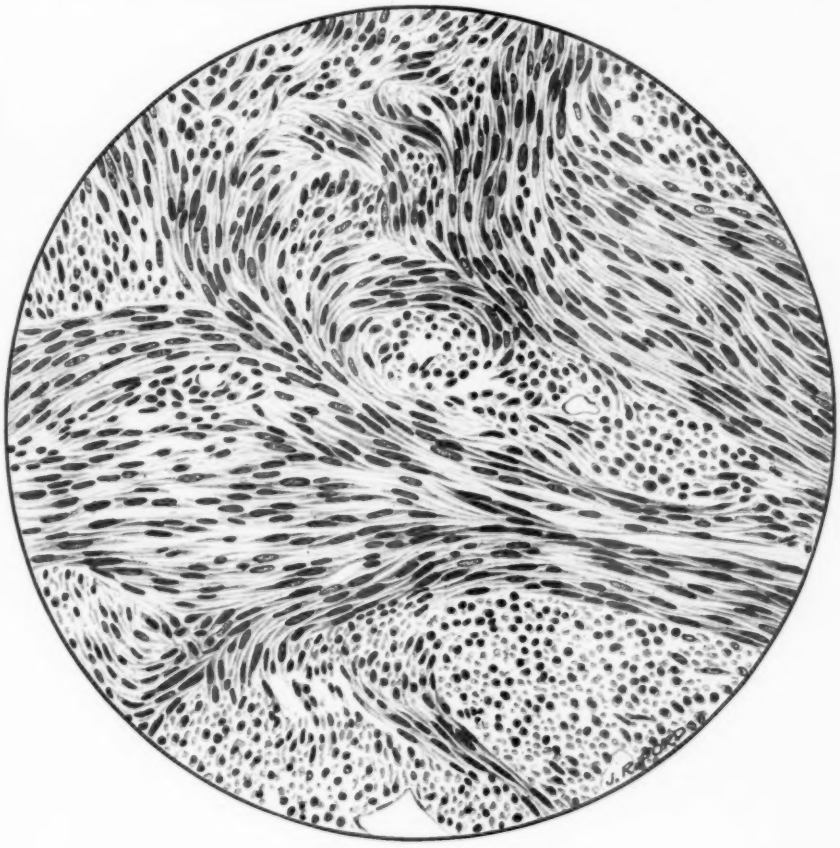

FIGURE X.

the jejunum 21 centimetres (six inches) from the duodeno-jejunal flexure. The growth was ulcerated on the mucous membrane surface. The lymphatic glands were not enlarged, and there were no secondary deposits.

Comments.—This case exemplifies the serious significance of vomiting blood and mucus with the simultaneous passage of several stools of bright blood and mucus.

Figure IX shows the lumen in two drawings in which the growth is viewed from the peritoneal and mucous membrane surfaces respectively. The peritoneal surface shows a small growth, yellowish-white in colour, projecting from the surface, with several vessels on its surface. The mucous membrane shows the ulceration of this surface of the growth.

Figure X is a microscopical section of the growth and shows a spindle cell sarcoma, the cells being remarkably uniform in size. There are numerous vessels in the lumen, lined by a single layer of endothelium. Further examination of the microscopical slide showed an area of the tumour, which is necrotic, the cells in this area staining a homogeneous pink colour and exhibiting no nuclei. The cells bordering this area are separated by clear spaces due to œdema of the intercellular spaces.

THE CARCINOMATA.

Carcinoma is an uncommon disease of the small intestine. We append in the accompanying table a series of statistics showing its relative rarity.

The Reference Quoted.	The Source of the Statistics.	The Figures.
Nothnagel: "Diseases of the Intestines and Peritoneum" (English Edition); quoted from Keyser.[22]	Autopsies at the Vienna General Hospital, 1870-1893.	41,838 autopsies, among which were 3,585 cases of carcinoma; 343 were of intestinal carcinomata, of which 7 were duodenal, no jejunal and 10 ileal cases.
Leichlinstern (quoted from Nothnagel).	Cases collected both from living and autopsy records.	757 intestinal cases, of which 17 were duodenal, 3 middle ileum, and 13 lower ileum.
Müller (quoted from Nothnagel).	From the Pathological Institute at Berne, 1886-1891.	5,621 autopsies, among which were 521 intestinal carcinomata, and of these 6 were duodenal and 3 in the rest of the small intestine.
Brill: *American Journal of the Medical Sciences*, 1904, Vol. CXXVIII, page 824.	Figures quoted from various sources.	2·5% only of intestinal cancers occur in the small intestine.
Zemann (quoted by Nothnagel).	—	In 21,624 autopsies, 3 duodenal, 6 ileal and no jejunal cancers were found.
Hemann (quoted by Nothnagel).	Patients dying in the general hospitals in Prussia, 1895-1896.	1,706 cases of intestinal cancer, of which 20 only were in the small intestine.
Lubarsch (quoted by Nothnagel).	Autopsies at the Pathological Institute at Breslau.	569 cases of intestinal cancer. Of these, 2 were duodenal and 2 in the rest of the small intestine.
Hinz (quoted by Raymond Johnson[20]).	From various sources.	584 cases of intestinal cancer, of which 18 were in the small intestine, excluding the duodenum.

The Reference Quoted.	The Source of the Statistics.	The Figures.
Sutton (quoted by Tatlow[25])	—	100 cases, of which 75 were rectal cases, 23 large intestine and 2 only in the small intestine.
Fergue and Chavin (quoted by Vickers).	—	88,031 cases (autopsies), among which 6,847 were cases of cancer; of these 642 cases of intestinal cancer, 39 only were in the small intestine.
"Encyclopædic Medica" (quoted by Black[30]).	—	Of 1,148 cases of cancer of the gastro-intestinal tract, 5 only occurred in the ileum.
Judd.[21]	Patients treated at the Mayo Clinic.	3,535 cases of carcinoma of the alimentary tract, 1,689 in the stomach, 1,822 in the large intestine, 24 only in the small intestine, and of these, 5 were duodenal, 11 jejunal, 6 ileal and 2 involved the whole of the small intestine, being present in multiple nodules.
Sir H. Waring.[45]	Patients treated at Saint Bartholomew's Hospital, 1900-1919.	14 cases of carcinoma of the jejunum and ileum, 270 of the large intestine, and 690 of the rectum.

Ewing and Hinz (quoted by Raymond Johnson, Raymond Johnson and Judd) sum up the statistics by stating that 3% only of intestinal carcinomata occur in the small intestine. Of these 3%, half occur in the duodenum (Hertzler, quoted by Waring), due doubtless to the presence of the papilla of Vater, with its relatively greater tendency to become carcinomatous. The remarkable immunity of the small intestine to carcinomatous change, as compared with the rest of the alimentary canal, is due to the absence of conditions producing chronic irritation of the lining mucous membrane, and the absence of sudden change in the type of the lining mucous membrane, such as a change from columnar to stratified epithelium.

The contents of the small intestine are fluid and alkaline, and present a great contrast to the solid lumps which traverse the œsophagus and stomach, to the acid contents of the stomach, or to the solid, sometimes inspissated, masses found in the large intestine.

There are no fixed, sharp bends in the small intestine against which the onflowing contents impinge, a factor having some influence on the location of carcinoma, as demonstrated, for example, by the occurrence of carcinoma of the caecum commencing in the caecal wall opposite the ileo-caecal orifice, also by carcinoma which often occurs at the hepatic and splenic flexures and at the pelvi-rectal junction.

The lumen of the small intestine narrows very gradually from the commencement of the jejunum to the terminal part of the ileum, and

it presents no abrupt narrowing comparable with the post-cricoid retro-branchial and cardiac portions of the œsophagus, or the pyloric ring of the stomach. In this connexion it is interesting to note that Bunting[36] quotes a case of Waldeyer and Birch Hirschfielf, in which a carcinoma of the small intestine arose at a point where the lumen of the bowel was narrowed by peritoneal adhesions.

The sudden transition in type of the epithelium of the mucous membrane of the small intestine with its intestinal villi to the epithelium characteristic of the large intestine at the ileo-caecal valve is doubtless one of the reasons why carcinoma is relatively frequent in this situation. Carcinoma of the ileum is commoner than carcinoma of the jejunum. Raymond Johnson states that carcinoma of the ileum is less rare than carcinoma of the jejunum. Robb[32] states that it is twice as common as carcinoma of the jejunum. Many case records make no mention of the exact site of the growth in the small intestine. Keyser[22] points out that amongst the statistics quoted by Nothnagel only in those of the Vienna General Hospital autopsies (1870-1893) and in the cases mentioned by Zemann is specific mention made of cancer of the jejunum, and in these long series there was no single case of carcinoma of the jejunum.

Newton and Buckley,[24] quoting from European statistics and reports of eight of the largest hospitals in the United States, point out that in 135,000 autopsies there were only 23 cases of primary adeno-carcinoma of the jejunum. Carcinoma of the jejunum occurs most often in the upper coils, and carcinoma of the ileum in the lower coils.

Carcinoma of the duodeno-jejunal flexure or of the terminal portion of the ileum is, however, rare (Case II of Tatlow and Case VIII of our series).

Age.—The average age of the carcinoma patients is forty-six and a half years. The youngest patient with carcinoma of the small intestine was a boy of three and a half years (Duncan[23]).

Sex.—Carcinoma of the small intestine is twice as common in men as in women.

Morbid Anatomy.

The naked eye appearances have been variously classified by different writers, some writers attempting to correlate the naked eye picture with the microscopical structure of the growth. We consider that there is no constant relationship between the naked eye appearance and the microscopical structure, with one exception, the argentaffin tumours.

The following classification describes the naked eye appearance of these growths:

1. Annular stenosing carcinoma.
2. Polypoid carcinoma.
3. Annular ulcerating carcinoma.
4. The argentaffin tumours, whose naked eye appearances are described later.

Raymond Johnson describes the colloid carcinoma as a separate type, but it would perhaps be better to regard it as a degeneration, which may affect any of the varieties described. Waring describes two classes, an annular columnar cell carcinoma with localized ulceration and constriction, and an adeno-carcinoma.

The two common types are the annular stenosing and the polypoid types, and Keyser's statement that the annular type is rarely seen, is curious and open to criticism.

The growths are occasionally multiple; Judd had several cases of multiple carcinoma of the ileum. They were both polypoid and annular in type. One of his was a case of carcinoma of the stomach and of the small intestine, and two others were cases of growths in both small and large intestines. Krompecher (quoted by Bunting[36]) records a case of adeno-carcinoma occurring simultaneously in the ileum, caecum and sigmoid.

Carcinoma of the bowel may simulate a tuberculous lesion or *vice versa*. Venot and Parcelier (quoted by Raymond Johnson) recorded two stenosing tumours of the bowel believed to be carcinomatous, which proved on microscopical examination to be tuberculous, and they refer to Chalmer's case of multiple deposits in the small intestine, believed to be tuberculous, which proved on microscopical examination to be colloid carcinoma.

Toisaer and Wade (quoted by Primrose[39]) record two cases regarded as carcinoma of the small intestine which proved on microscopical examination to be tuberculous. Hinz (quoted by Primrose) also records two cases of a similar nature. Keyser states that sudden perforation of the growth is not uncommon. Five out of twelve cases of carcinoma of the jejunum collected by him had perforated.

A localized abscess may develop in connexion with the growth, or a fistulous communication may be established with some other viscus. Raymond Johnson refers to water colour drawings by Sir Robert Carswell of three cases of carcinoma of the jejunum, which had perforated. Voelcker[27] records a case of carcinoma of the jejunum, which had formed a fistulous communication with the transverse colon. Ketchley records a case of carcinoma of the ileum which had formed a fistulous communication with the rectum. Fagge[33] successfully resected a carcinoma of the jejunum which had extended into and involved the transverse colon.

Case VI: Carcinoma of the Jejunum.

Alfred M., aged fifty-seven years, a printer by trade, was admitted to King's College Hospital in June, 1929, complaining of stomach trouble. He had first noticed abdominal pain a year previously. Very slight at first, the pain had gradually been getting more severe and the onsets more frequent, especially so in the last three months. The pain was sharp in character and came on half an hour after food. During the last two months he had suffered from flatulence after meals. He now had a constant tight and uncomfortable feeling in the stomach, and pain and distension followed every meal; on some occasions it was more

severe than at others. He had been on light diet for the last three months, and had lost 6·3 kilograms (a stone) in weight. There was no history of vomiting and he was constipated.

On examination, the abdominal wall was found to be rigid on both sides. A hard oval swelling 7·5 by 5·0 centimetres (three by two inches) appeared every few minutes in the umbilical region and was easily palpable. Visible peristalsis was seen.

FIGURE XI.

A blood count yielded the following result:

Red blood corpuscles, per cubic millimetre	4,760,000
Hæmoglobin value	80%
Colour index	0·84
White blood corpuscles, per cubic millimetre	8,400
Polymorphonuclear cells	81·5%
Lymphocytes	16·59%
Eosinophile cells	1·50%
Large hyaline cells	0·50%

The Wassermann test yielded no reaction.

On July 24, 1929, an operation was performed under gas and oxygen. A fifteen centimetre (six inch) paramedian incision was made and the small intestine was drawn out of the wound. Forty-five centimetres (eighteen inches) from the duodeno-jejunal flexure a distended end of the jejunum was seen, and a hard lump was palpated in it. The great omentum was firmly adherent to this area.

A good many enlarged, soft, probably inflamed lymphatic glands were seen in the mesentery. Chyle-distended lymphatic vessels were also visible in the mesentery. The great omentum was ligatured and divided, the adherent portion on the coil of jejunum being left. The bowel, including fifteen centimetres (six inches) on each side of the tumour, was resected and an end-to-end anastomosis effected.

This patient was progressing well for nineteen days after the operation, when he developed pneumonia, which proved fatal on the twenty-fourth day after the operation.

Figure XI shows a dilated loop of jejunum. The bowel wall is hypertrophied both proximal to and distal to the site of the growth, and the bowel immediately proximal to the growth is more dilated than the rest of the coil, the circular

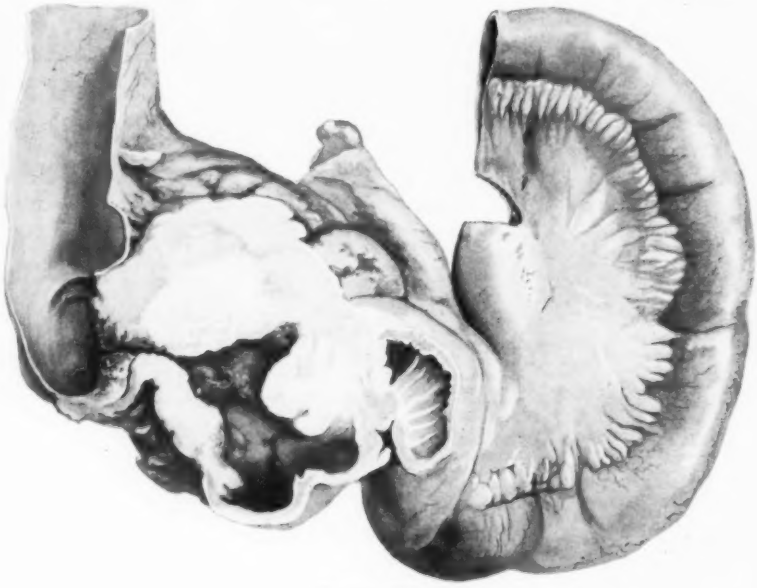

FIGURE XII.

folds of the mucous membrane having been effaced by distension. The growth is a white annular stenosing tumour, extending to the peritoneal coat. The lumen has been reduced to a small channel, the size of a crow quill, running through the centre of the growth. The great omentum is adherent to the bowel in the region of the tumour and of the proximal dilated portion. Several enlarged lymphatic glands were seen in the mesentery. The peritoneal coats of the bowel and of the mesentery show congested vessls and strands of fibres. Microscopical examination of the lymphatic glands showed inflammatory changes and a very typical columnar-celled carcinoma.

Case VII: Carcinoma of the Ileum.

Frederick P., aged sixty-three years, was admitted to King's College Hospital suffering from shortness of breath and abdominal distension. He had never suffered from abdominal pain, but during the last six months he had suffered from anorexia, and lost about 6·3 kilograms (a stone) in weight. He had never vomited.

On examination, the abdomen was found to be inordinately distended, visible peristalsis was seen, and a lump was palpated just below and to the right of the umbilicus. The lump was freely movable and not painful. There was no sign of free fluid in the abdominal cavity. An exploratory laparotomy was done through a right paramedian incision. An extensive malignant growth of the terminal

FIGURE XIII.

part of the ileum came into view. The terminal part of the ileum, the caecum and the ascending colon were excised together, and a lateral anastomosis was effected between the ileum and the transverse colon. The omentum was sutured over the anastomosis. This patient made an uneventful recovery.

Figure XII shows the terminal part of the ileum, the caecum and the ascending colon. There is a large growth in the terminal part of the ileum extending into the caecum. It has destroyed all the coats of the ileum, and is seen to be a nodular mass extending more especially into the angle between the ileum and the

caecum. On section, the growth is seen to be white, and has encroached into the lumen of the bowel, which is reduced near the ileo-caecal orifice to a narrow, tortuous passage, the size of a quill.

Figure XIII shows the growth to be an adeno-carcinoma. There are numerous glandular spaces lined by several layers of irregularly arranged cells with deeply staining nuclei. There are red blood cells in some of the spaces. The tumour has infiltrated the muscle coats of the intestine.

Case VIII.

Case VIII was published in full by one of us (C.P.G.W.) in *The British Journal of Surgery*, Volume XIV, 1926, page 525. The following is an abstract of the history.

Mrs. E.T., aged fifty-three years, first complained of abdominal pain in October, 1923, ten months after her menopause. The pain was chiefly in the epigastrium, but was often referred to the hypogastrium. On examination, a large uterine fibroid could be palpated in the hypogastrium. She was admitted to the Samaritan Hospital, and in January, 1924, Mr. W. Gilliatt performed a subtotal

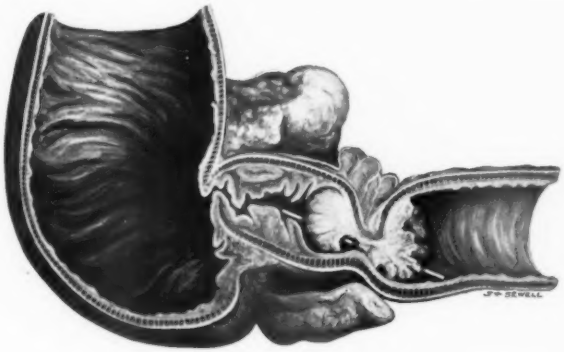

FIGURE XIV.

hysterectomy for fibroids. The left ovary was removed, as it was found to be in a cystic condition, and the appendix was also removed. There was no sign of obstruction, and the intestine was not distended.

In April, 1924, four months after her operation, the bowels began to be troublesome, very strong purgatives having to be taken to produce a motion. The abdomen became distended and there was occasional vomiting. The abdominal distension became more marked, and the patient was admitted to King's College Hospital on May 1, 1924.

On examination the abdomen was found to be very distended except in the flanks; the signs seemed to point to obstruction in the small intestine. A specimen of the vomit was examined, and considered to be a regurgitant vomit from the small intestine owing to the presence of fatty acids and soaps. A provisional diagnosis of obstruction to the lower part of the small intestine was made, and the question whether or no the terminal loop of the ileum had become adherent to the stump of the cervix was discussed. This, however, was ruled out of court, since a long time had elapsed between the operation of subtotal hysterectomy and the commencement of symptoms of obstruction. As the symptoms did not improve, a laparotomy was decided upon.

On May 3 an operation was performed under "Stovaine" anæsthesia, a little ether also being given by the open method. The abdomen was opened just to the right of the mid-line by a subumbilical incision. The small intestine was found to be distended, while the large gut was collapsed. A small hard annular growth was found in the ileum, about 3·75 centimetres (one and a half inches) from the ileo-caecal valve. The stump of the cervix was quite free, and there were no adhesions in the pelvis. A lateral anastomosis was effected between the lower part of the ileum and the ascending colon, and the abdomen was closed. On May 19 the abdomen was again opened under "Stovaine" and ether anæsthesia by a right rectus incision. The short circuited portion of the gut was excised, namely, the last 15 centimetres (six inches) of the ileum, the caecum and the lower part of the ascending colon. The abdomen was closed in layers. Recovery was uneventful.

FIGURE XV.

The tumour (Figure XIV) gave rise to a tight annular stricture, and on microscopical examination proved to be a columnar celled carcinoma. There was no sign of growth in the glands at the root of the mesentery or in those in the ileo-caecal angle.

When last seen, January, 1931, nearly six years after her operation, the patient was in good health.

Case IX.

Case IX is of interest because no operation was performed, although symptoms of small intestine obstruction were present for nearly six months.

Mrs. E.A., aged sixty years, a hard working woman, had always enjoyed good health up to five months previous to her death. Her symptoms started with occa-

sional vomiting which apparently had no relation to food, but the patient experienced some pain prior to the attack. The pain was sometimes most marked in the right iliac fossa, while at other times it was situated under the right costal margin. Her doctor put her on a strict diet and her symptoms subsided. About

FIGURE XVI.

every month or six weeks, however, the vomiting and pain returned, and the patient was kept on practically a fluid diet. Operation was strongly advised by her doctor, but this the patient refused. On one occasion her doctor examined her while she had an attack of pain and vomiting, and distinctly felt a lump just below and to the right of the umbilicus. The patient continued to do her household duties until the day before her death, when she was seized with a sudden and severe attack of pain and vomiting. Her doctor gave her an injection of morphine, but this did not relieve the pain, which was so severe that she

consented to have an operation. On admission to King's College Hospital she was in such a debilitated condition that an operation was not performed. The patient died three hours after admission. At the autopsy a hard annular growth was found in the terminal part of the ileum, about 30 centimetres (a foot) from the ileo-caecal valve. On opening the gut a hard annular growth (Figure XV) was seen to obliterate the lumen of the intestine almost completely; the annular growth left a small central aperture only. There were no secondary deposits anywhere in the abdominal cavity. The intestine above the growth was somewhat dilated and hypertrophied.

On microscopical examination the tumour was seen to be a columnar celled adeno-carcinoma (Figure XVI).

THE ARGENTAFFIN TUMOURS.

Bunting (1904) gave a good description of the argentaffin tumours, recording a case of his own together with the reports of six cases which he had found in the literature on the subject. These early cases were all detected during a routine *post mortem* examination, death having occurred from some other cause.

Multiple opaque white firm nodules, three to seven millimetres in diameter, were found in the mucosa of the intestine. There was no ulceration, and in these early cases no secondary metastases. On microscopical examination the nodules were seen to consist of clumps of spheroidal cells embedded in a stroma of fibrous tissue, and the nodules had invaded the muscular coats of the bowel. The clumps of cells were all of the same size, giving a very characteristic microscopical picture.

The question arose whether or no metastases ever occurred in these cases. In 1890 Ravisan recorded a case of primary carcinoma of the ileum in a woman who died shortly after admission to hospital with marked cachexia and metastatic nodules in the liver. At the *post mortem* examination numerous secondary metastases were seen in the liver, and a polypoid tumour was found in the ileum.

The wood-cut illustrating Ransom's paper depicts a tumour of the same histological structure as was seen in Bunting's case.

The name carcinoid tumour was suggested by Oberndorpfer in 1907. He also showed that these tumours might occur in any part of the alimentary tract from the cardiac end of the stomach to the anus. Krompecher suggested that the tumours were of similar nature to basal cell carcinomata of the skin, emphasizing the palisade-like arrangement of the cells bordering each clump of cells. The absence of metastases in the earlier cases supported this view by giving a further point of similarity to the basal cell carcinomata.

Masson, using a modification of Fontana's ammoniacal silver method, showed that the tumour cells had protoplasmic granules, which reduced silver cells and stained black. A valuable method of differentiating these tumours from the carcinomata was established by this method.

Gosset and Masson, 1914, noticed the similarity of the silver reaction to the Kultschitsky cells of the crypts of Lieberkühn, from which they supposed the tumours arose, and suggested the name "argentaffin tumour."

The commonest sites of these tumours are the appendix and the small intestine. The tumours are composed of clumps of polygonal cells embedded in a fibrous tissue matrix. The cell clumps are all of the same size, the outermost cells are columnar in shape and arranged as a palisade round the clump. The inner cells are polygonal. The nuclei are spherical and show no mitotic figures.

Oxiphyl granules are present in the outer borders of the cells of the cell protoplasm, especially in the marginal or palisade cells.

The cells stained by Masson's silver solution show black granules in their protoplasm. A series of cases have been recorded which conclusively settle the question of the malignancy of these tumours.

They are undoubtedly malignant, but in many of the earlier cases no metastases had occurred at the time of death. We append a table from Zachary Cope's paper[40] giving a list of cases of argentaffin tumours of the small intestine which have metastasized.

Observer and Reference.	Position of Primary Growth.	Metastases.
Stewart and Tayler: *Journal of Pathology and Bacteriology*, 1926, Volume XXIX, page 136.	9 cases in small intestine. 9 cases in the appendix.	12 metastases in peritoneum. 7 metastases in liver. 6 metastases in lymphatic glands. 1 metastasis in pleura.
Notthaft: *Deutsches Archiv für Klinische Medicin*, 1895, Volume LIV, page 555.	Jejunum.	Lymphatic glands.
Saltykow: *Ziegler's Beiträge zur Pathologischen Anatomie und Physiologie*, 1912, Volume LIV, page 559.	Duodenum. Ileum.	Lymphatic glands. Lymphatic glands.
Dietrich: *Frankfurter Zeitschrift für Pathologie*, 1913, Volume XIII, page 390.	Ileum. Ileum.	Liver and peritoneum. Liver and lymphatic glands.
Cuthbert Dukes and Lockhart Mummery: *Journal of Pathology and Bacteriology*, 1926, Volume XXIX, page 308.	Ileum.	Peritoneum. Liver and lymphatic glands.
Stewart (unpublished cases).	Ileo-caecal region. Small intestine.	Lymphatic glands. Lymphatic glands and liver.
Newcomb: Read before Section of Pathology, Royal Society of Medicine, January 15, 1929.	Ileum.	Lymphatic glands.

Further Cases.

Zachary Cope's case was an argentaffin tumour of the ileum with numerous secondary deposits in the peritoneum and in the left testicle.

Gaspar's[41] case was an argentaffin tumour of the ileum with metastases in the liver. These tumours occasionally produce local intestinal symptoms. Primrose's patient,[39] an octogenarian who was operated on for acute intestinal obstruction, had an argentaffin tumour in the ileum.

METASTATIC TUMOURS OF THE JEJUNUM AND ILEUM.

A secondary deposit in the jejunum and ileum may be a peritoneal implantation growth from transcœlomic spread, but in some cases the tumours are submucosal and they must therefore have been disseminated either by the blood stream or through the lumen of the bowel. A brief description of a few illustrative cases from the literature on the subject will indicate the possible modes of dissemination.

In 1893 Perry[42] described a case of multiple secondary deposits of round cell sarcoma which were situated in the mucosal surface of the bowel, in a man aged forty-five years, with a sarcoma of the right tonsil. Only one of the nodules had penetrated the peritoneal coat. This case suggests the possibility of dissemination along the lumen of the bowel, but does not exclude the possibility of a blood stream dissemination.

In 1897 Rolleston[43] described a case in which a melanotic tumour of the eye had been excised two years previously. This patient had numerous secondary deposits all over the body, and had numerous small tumours, varying in size from a pea to a pin's head, on the mucosa of the intestine. Microscopical examination demonstrated the submucosal position of the smaller tumour, a convincing proof of a blood stream dissemination.

Dickson Wright (1930) described a case which can only be explained in the theory of a blood stream dissemination. A male patient had a melanotic tumour near the nipple, for which an operation on the lines of a radical operation for carcinoma of the breast was performed. Eighteen months later he complained of indigestion, but an X ray examination revealed no abnormality. Three months later he was operated on for acute intestinal obstruction and the small intestine was resected for a large secondary melanotic growth. The patient died, and at *post mortem* examination no other secondary deposits were found.

SYMPTOMS AND PHYSICAL SIGNS.

A small tumour will produce no symptoms or physical signs, and will be detected only in the course of a routine *post mortem* examination. The benign tumours will naturally predominate in this group of cases, but some cases of malignant disease may progress to the stage of marked cachexia from secondary deposits without giving rise to any symptoms or signs referable to the bowel.

A submucous polypoid tumour will be very liable to produce intussusception which will give rise to characteristic symptoms and signs. Elliot and Corscaden collected records of 300 intussusceptions in adults, 100 of which were due to intestinal tumours, 60 being benign and 40 malignant.

The predominance of benign tumours, in spite of the inclusion of the large bowel in the survey, is due to the larger proportion of the pedunculated submucosal type amongst the benign tumours.

Elliot and Corscaden give the following list of small intestine tumours from their series of cases:

	Benign.	Malignant.
Duodenum	0	1
Upper jejunum	1	0
Lower jejunum	0	0
Jejunum (exact site not stated)	4	2
Upper ileum	0	1
Lower ileum	5	1
Ileum (exact site not stated)	5	2
Small intestine (exact site not stated)	4	3
	19	10

An intussusception generally produces signs of acute intestinal obstruction, but in some cases there were prodromal symptoms, and in one instance an acute intussusception was an unexpected finding during laparotomy for some other condition.

Elliot and Corscaden summarize the findings in their cases in a table which is slightly modified below.

Benign Tumours—

(*a*) Acute intestinal obstruction symptoms and signs.
(*b*) Either: 1. A history of attacks of acute intestinal obstruction, relieved spontaneously.
2. A history of chronic constipation or indigestion.
3. A history of intermittent colic with or without vomiting, and concurrent constipation, with intervals of complete freedom.
4. A very few cases of chronic intussusception.
5. An occasional case in which an intussusception is an unexpected operation finding during laparotomy for some other lesion.

Malignant Tumours—

1. Acute intestinal obstruction.
2. Cases with a previous history of a primary growth elsewhere, the intussusception being produced by a secondary deposit in the small intestine.
3. The largest group of cases in which there is a history of gradually increasing intestinal obstruction, terminating in acute obstruction.

Many of the conditions mentioned above are not due to intussusception, but were produced by the presence of the tumour which at a later date led to the formation of intussusception.

The passage of blood *per rectum* does not occur in many cases, and the red current stools of intussusceptions of infancy are practically never noted.

In Case I and Case III of our series there had been no blood in the stools, while in Case II a large amount of blood was noted in the stools.

The prodromal symptoms may be due to intestinal colic due to irregular peristalsis set up by the tumour; it may be due to the production of an intussusception which spontaneously reduces itself, or it may be due to the bulk of the tumour itself.

Acute intestinal obstruction occurs when the lumen of the bowel has been reduced to the size of a quill, and in such cases there is generally a history of attacks of acute intestinal colic, associated with nausea

and vomiting occurring at intervals for several months before the final attack of acute obstruction. There is a gradually increasing difficulty in obtaining a regular action of the bowels, and the abdomen may become more and more distended. Vomiting and sickness of occasional occurrence at first, become more frequent as time goes on. These prodromal symptoms are produced by the bowel, which becomes dilated and hypertrophied in its attempt to propel its fluid contents through the ever increasing size of the barrier produced by the tumour.

Pain.

A history of violent attacks of intestinal colic is not unusual in cases which terminate in an attack of acute obstruction. It might be expected that the higher the obstruction, the more marked would be the relation of pain and vomiting to food, but this is not exemplified in practice. Nor is this altogether surprising, for it is well known that the taking of food into the stomach may be followed soon after by peristaltic waves in the ileum. The pain in these cases is produced by excessive peristaltic contractions, and, therefore, pain may be noted soon after food, even in the case of an ileal tumour. In Case VI, a case of carcinoma of the jejunum, the pain was definitely related to taking food.

In Raymond Johnson's third case pain occurred after food, and vomiting relieved the pain, yet in this case the symptoms were due to a growth 15 centimetres (six inches) above the ileo-caecal opening. In many cases pain has no relation to taking food, and may occur at any time.

Vomiting.

The vomit is bile stained, which distinguishes it from the vomit of pyloric obstruction. In a typical case there is first a history of nausea and of vomiting associated with attacks of colicky pain. As time goes on, vomiting becomes more frequent, until finally the case terminates as a case of acute intestinal obstruction with the typical vomiting of such a condition. There is no blood in the vomit in most instances.

In a few cases in which ulceration of the growth with hæmorrhage has occurred, the vomiting of blood may be a marked feature. In a few, the vomit consisted of blood and mucus (Case V), but this is distinctly rare.

Emaciation and Secondary Anæmia.

Emaciation may be a marked feature of the case. The patient with multiple secondary deposits is always emaciated, and in many emaciation is the predominant sign of disease. Hæmorrhage from a tumour may produce a severe type of secondary anæmia. The rarity of marked hæmorrhage from the growth accounts for the rare occurrence of secondary anæmia in these cases.

Peristalsis.

Visible peristalsis is an important and valuable diagnostic sign of intestinal obstruction. Its presence indicates that the condition is an obstruction of some standing. There are two fallacies with regard to this sign. In a thin abdominal wall the normal coils of intestine are visible through the wall, and visible peristalsis, which is merely the normal peristalsis of the gut, is present. The late Mr. H. L. Barnard stated that in such a normal person, palpation of the gut would show that, unlike a case of obstruction, the gut did not harden and become more palpable during the duration of the peristaltic wave.

The other fallacy is to mistake gastric peristalsis for intestinal peristalsis. Raymond Johnson makes careful notes on the occurrence of visible peristalsis in three cases observed by him. In the first case there was marked visible peristalsis in a coil of gut lying transversely above the umbilicus. The peristaltic wave passed from right to left, clearly differentiating it from a case of pyloric obstruction in which the gastric peristalsis would occur from left to right. In the second case, a coil of intestine lay transversely below the umbilicus, but the direction of the peristaltic wave could not be accurately determined. In the third case, he observed the typical ladder or organ-pipe pattern, which is produced only by peristalsis of the small intestine. One coil of the pattern was infraumbilical, and in this the direction of the peristaltic wave was from right to left.

A Palpable Tumour.

A palpable tumour may be the growth itself, it may be an intussusception produced by the growth, or, as in a case recorded by Raymond Johnson, it may be a dilated loop of bowel above the growth.

Raymond Johnson states that a palpable tumour due to a carcinoma is rare, but this may equally be said of all tumours of the jejunum and ileum.

The small intestine, lying, as it does, below the transverse colon, is infraumbilical in position. The jejunum lies mainly above and to the left, and the ileum below and to the right. One would therefore expect that tumours of the jejunum, in virtue of their position and of their weight, would lie in the left iliac fossa, and tumours of the ileum in the right iliac fossa. Keyser made a careful analysis of twelve cases of carcinoma of the jejunum. A palpable tumour was noted in no less than six cases, and its absence noted in three. Five out of these six jejunal cases were in the left iliac fossa, and in one it lay in the right iliac fossa. A tumour was noted in three of our cases (Cases IV, VI and VII) and was near the umbilicus in all three, two being jejunal and one a tumour of the terminal part of the ileum.

Lakey regards the free mobility of the tumour as a signficant point in the diagnosis, and records two personal cases in which the tumour was freely movable.

In two of our cases special note was made of the free mobility of the tumour (Cases IV and VII).

Corner and Fairbank state that an abdominal tumour was noted in 18 out of 65 cases of sarcoma of the small intestine, and in 11 out of 20 cases of sarcoma of ileo-caecal region. The benign tumours rarely attain a size which would be palpable through the abdominal wall. King refers to a case of fibro-myoma of the jejunum twice the size of a child's head (Case XXVII of his series) and another case of fibro-myoma twice the size of a normal uterus (Case CCCCXXIX of his series), but such cases are exceptional.

It is noteworthy that a tumour is not always palpable in cases of intussusception. Three of our cases were complicated by intussusception, and in two (Cases I and II) special note was made of the fact that no palpable tumour was present, while in the third case a palpable tumour was found (Case III).

Accessory Aids to Diagnosis.

A patient admitted for acute intestinal obstruction will naturally be operated on before any accessory aids to diagnosis can be used. When such urgent symptoms are not present, these aids to diagnosis may be made use of. The barium meal has been used in a few cases.

In some the barium meal reveals no abnormality, a not unexpected finding in view of the fluid nature of the contents of the small intestine (Tatlow, Case III, and Primrose), while Tatlow records a case in which the X ray examination was misleading, an irregularity of the lesser curvature suggesting a diagnosis of carcinoma of the stomach, whereas at the operation a carcinoma of the duodeno-jejunal flexure was found. Robb states that the X ray examination is of no value in these cases.

We have recorded a case in which the X ray picture was diagnostic of an obstruction in the small intestine, and we have already stressed the importance of the various features of the X ray photograph. Raymond Johnson distended the stomach with carbon dioxide, and the colon with air, in order to demonstrate the independence of a palpable distended coil of small intestine as far as these viscera were concerned. The necessity for such an examinational method is unlikely to arise very often, and it cannot be considered as one free from danger.

The chemical test for occult blood was done in a few cases, and a positive result obtained where the tumour had ulcerated through the mucous membrane. The test does not materially assist in diagnosis, and has, therefore, been seldom used. An intestinal tumour may secrete mucus which is either vomited or passed *per rectum*, but in many of these cases the mucus is small in quantity, and is unrecognizable in the stools. An epithelial tumour, adenoma or carcinoma, is more likely to secrete mucus, but clinical evidence of this is unusual. Hæmorrhage from the tumour after ulceration into the lumen of the bowel may give rise to hæmatemesis and blood in the stools. Sometimes bleeding con-

stitutes the chief feature of the case, and death occurs from hæmorrhage (Case V of our series). In the rare hæmangiomata hæmorrhage is the usual clinical finding.

Observations on the Operation Table Which Assist in Diagnosis.

An annular stenosing tumour is malignant, as no benign tumour assumes this form. A large subperitoneal tumour infiltrating the bowel wall is a rare but characteristic type of growth whose naked eye appearance is diagnostic. A submucous pedunculated tumour may produce a characteristic dimple on the peritoneal surface. A subperitoneal lipoma is diagnosable at sight, and other types of benign subperitoneal tumours may be identifiable. An intussusception complicating a tumour is, in the majority of cases, associated with a benign tumour, as, according to Elliot and Corscaden, intussusception was present in 19 cases of benign tumours and in 10 cases only of malignant tumours.

If the intussusception is reducible, the tumour will be palpable through the bowel wall, and it is generally situated at the apex of the intussusception. Wardell draws attention to cases in which the tumour setting up the intussusception is not at the apex, but situated on the entering layer of the intussusception.

It should, therefore, be a routine practice to palpate the bowel proximal to the apex after reduction in order to detect the possible presence of a tumour which may be situated there. Blood stained fluid in the peritoneal cavity is nearly always indicative of an intussusception of the bowel (Case II). In rare cases, stenosing tumour of the bowel may be due to tuberculosis. Venot and Parcelier, quoted by Raymond Johnson, describe two cases, and Sussig describes two cases. The rare plasma cystomata may closely simulate malignant tumours, and they have nearly always been treated as malignant tumours on the operation table. No case should be abandoned as hopelessly inoperable in view of these fallacies, and the mechanical block should be remedied by a short circuit operation, even if the lumen be fixed. Multiple small secondary nodules in the peritoneum closely simulate miliary tuberculosis, and in some cases a definite diagnosis is impossible on the operation table. In these doubtful cases a subsequent microscopical examination will settle the question.

THE TREATMENT.

Local excision of the growth is feasible in a few cases only, but was carried out with success in Case II of our series. In the majority of cases resection of the affected loop of gut with end-to-end anastomosis gives very good results.

Resection of the mesentery includes resection of the mesenteric lymphatic glands. The intussusceptions may be reduced and the tumours treated as indicated above, or the unreduced intussusception may be resected and an en-to-end anastomosis performed. Where the obstruction is so advanced as to jeopardize the success of resection and end-to-end

anastomosis, the prognosis is bad, and description of the various operative procedures which may be undertaken in these cases does not come strictly within the scope of this article.

An inoperable fixed growth requires a short circuit operation in order to prolong life, although this may be for a short time only. The rare possibility of mistaking a granuloma for a tumour makes the undertaking of this operation worth while.

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THE INNERVATION OF THE RENAL CAPSULE AND ITS RELATION TO LOCALIZED RENAL PAIN.

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Introduction.

In the study of renal pain the attention of most observers has been attracted, quite naturally and very often exclusively, in the direction of the urgent and disabling pain of renal colic, with the result that the less dramatic but equally significant symptom of localized renal pain scarcely seems to have received, up to the present, its due measure of analysis and study. The clinical features of colic, its severity, its intermittency, its typical distribution and radiation, and the associated muscular rigidity and tenderness are classical, and its origin in spasmodic contraction of the plain muscle of the pelvis and ureter and consequent reflex nature are established beyond all doubt.[1] On the other hand, while the features of localized renal pain, its constancy, its dull nature and the absence of radiation are well recognized, the problem of its mechanical origin and the question of the structures where the pain originates have received little attention.

In view of the nature of the pain it is obvious that it cannot be due to spasmodic contraction of plain muscle. The alternative, which is in complete accord with its clinical features, is to regard it as due to increased tension in the kidney, affecting not necessarily the pelvis only, but almost certainly the parenchyma and capsule as well. It was decided, therefore, to carry out an investigation of the innervation of the renal capsule to determine whether or not an afferent nerve supply exists, and, if so, whether it can be concerned with the production of localized renal pain. With the assistance of this information, an attempt has been made to arrive at some conclusion regarding the mechanical basis of localized renal pain due to various lesions and the relative parts played therein by capsule and pelvis.

The Sympathetic Nervous System.

Before considering the nerve supply of the renal capsule, it is necessary first to discuss briefly the sympathetic nervous system from which this innervation is derived.

The essential difference between the cerebro-spinal and the sympathetic nervous system is that while in the cerebro-spinal nervous system the connector and excitor neurones of the reflex arc are located in the central nervous system (in the spinal cord in the dorsal and ventral horn respectively), in the process of development of the sympathetic nervous system the excitor elements have left the central nervous system, and are found in the different sympathetic ganglia throughout the body, and the connector neurones lie in the lateral horn.[2] In other words, synapses occur in the course of the sympathetic efferent path, and Langley[3] and Ranson[4][5] have shown that each efferent fibre synapses once, and once only, between the point of exit of the pre-ganglionic fibre from the brain or spinal cord and the ultimate distribution of the post-ganglionic fibre in the tissues of the body. The efferent fibres to the upper urinary tract run largely in the splanchnic nerves, whose efferent fibres are uniformly pre-ganglionic,[6] and the neurones of the renal plexus mark the termination of such of these fibres as have failed already to form synapses in the ganglia they have traversed. The pre-ganglionic fibres are small and medullated, while the post-ganglionic fibres, though principally non-medullated, are not necessarily so.[5] Medullated efferent fibres, whether pre-ganglionic or post-ganglionic, are of small size.

The afferent fibres differ from the efferent in that their course is interrupted by no synapses.[7] They are structurally identical with the afferent fibres of the somatic system. In the posterior roots non-medullated nerves are well in excess,[8] while the afferent medullated fibres from the viscera vary in size, no one size greatly predominating.

Thus while non-medullated nerves in the tissues may be either post-ganglionic efferent or afferent, small medullated nerves present in any number are probably afferent, while medullated nerves of medium and especially large[9] size are definitely of afferent nature.

THE INNERVATION OF THE RENAL CAPSULE.

Gross Anatomy.

The capsular nerves are derived entirely from the renal plexus. Before it enters the hilum of the kidney, the renal plexus gives off amongst other branches a few small twigs which pass on to the renal capsule and become lost in it.

Centrally the renal plexus is derived mainly from the cœliac ganglion;[10][11] this brings it into relation with the greater splanchnic nerve, from which it also occasionally receives a branch direct.[12]. In addition, it is connected with the lesser splanchnic, which ends in the aortico-renal ganglion,[11] or again sometimes sends a small branch direct,[13], the first lumbar sympathetic ganglion,[12][14] the aortic plexus[15] and the vagus.[16]. The *splanchnicus minimus*, a small inconstant nerve, runs from the last thoracic ganglion to the renal plexus.[13]

Microscopical Anatomy.

Technique.

Several techniques were used, of which two yielded reliable results.

The Methylene Blue Technique.—The German preparation usually employed for *intra vitam* staining being unobtainable, an English dye, Gurr's "methylene blue for injection," was used and appeared to give equally good results. The method of staining by simple immersion, as described by previous workers,[17][18] was used. Fresh renal capsules were placed in a one in 4,000 solution of methylene blue in normal saline solution at body temperature, exposed frequently to the air, and examined microscopically from time to time. When the nerves appeared, fixation was carried out in a saturated solution of ammonium molybdate at 0° C. for four hours, washing, dehydration and clearing being done at the same low temperature, and the capsules were finally spread out and mounted in balsam. Though for the staining of nerves in tissues such as voluntary muscle, intestine or ureter, this technique is quite reliable, when applied to renal capsule it was found extremely capricious, a large proportion of failures occurring.

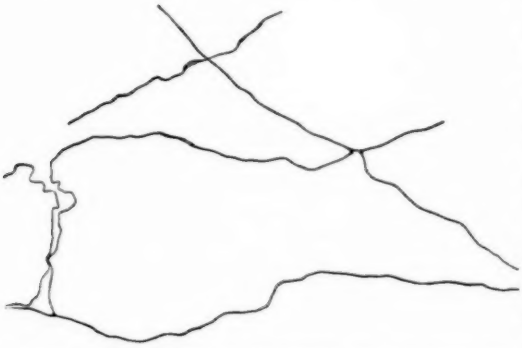

FIGURE I. Fine fibres of *nervi proprii*, showing nerve net formation in the human. After Stöhr. Schultze's silver-reduction technique. × 500.

The Gold Chloride Technique.—Ranvier's gold chloride technique[19] also gave useful results. The tissues were placed in a mixture of four parts of 1% gold chloride solution to one part of pure formic acid for ten to fifteen minutes, then reduced in the dark in 25% formic acid for three to four days, and finally washed, dehydrated, cleared and mounted in balsam. This technique, on the whole, gave rather more constant results than did methylene blue, with the added advantage that the blood vessels in most cases were extensively impregnated.

Most of the work was carried out on material obtained at operation or autopsy from dogs, rabbits and guinea-pigs. Fresh material obtained at the abattoirs from sheep and pigs was also used, but was not quite so satisfactory. Frogs were also studied. Owing to the difficulty in obtaining sufficiently fresh tissue, no attempt to investigate human tissues was made.

Previous Work.

Till recent years little attention has been paid to the innervation of the renal capsule. In 1898 Dogiel,[20] in the course of an investigation of the innervation of the blood vessels in general, described small terminations which he believed to be sensory, in the adventitia of the capsular arteries. Three years later Smirnow[21] described a plexus of medullated and non-medullated nerves accompanying the capsular vessels, some ending in the vessel walls and others terminating freely in the capsule. Koelliker[22] gives a similar brief description, after which no further references can be found till twenty-two years later, when Stöhr[23][24] awakened interest in the subject. Working with a recently elaborated

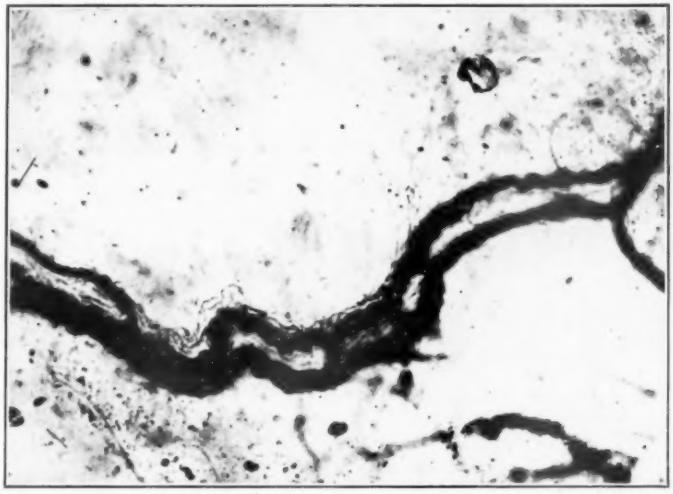

FIGURE II. Non-medullated nerve fibres accompanying capsular vessels in the sheep. Gold chloride. ×198.

silver technique[25] and using small pieces of human capsule, he described nerves bundles 60 to 80 microns in diameter, not related to the blood vessels, both the nerve bundles and the individual nerve fibres subdividing and anastomosing to form a closed plexus, without any free endings, in the form of a nerve net. These nerves he designated the *nervi proprii* (see Figure I). Two years later Lehmann,[26] using the same technique, confirmed the fact that two distinct groups of nerves exist in the renal capsule of man and of various laboratory animals, illustrating them for the first time photographically. He does not, however, mention the presence of a nerve net such as Stöhr describes. Fischer,[27] whose original paper is not available, apparently obtained similar findings. Recently Kaufmann and Gottlieb[28] have briefly described a rich network

of medullated and non-medullated fibres in the capsule, accompanying the blood vessels and lymph vessels.

Present Findings.

In the frog the innervation of the very delicate renal capsule was found to take the form of a typical nerve net without free endings, investing and surrounding the kidney. In mammals, however, the arrangement is rather more complex. The nerve supply of the capsule is twofold: vasomotor and specific.

The vasomotor nerves follow the blood vessels exclusively, and are all non-medullated (see Figure II). Like the blood vessels, they reach

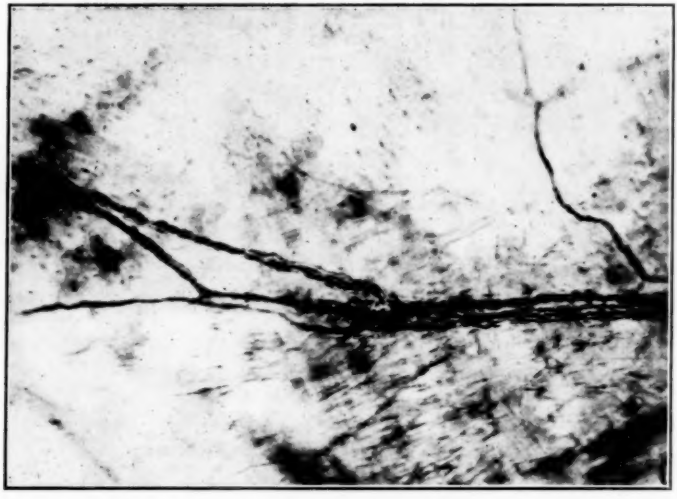

FIGURE III. Bundle of mixed nerve fibres in association with, but not related to, capsular vessels in the sheep. Gold chloride. × 120.

the renal capsule by two paths: (*a*) being derived directly from the renal plexus and accompanying the small arterial capsular twigs which arise in the hilum of the kidney from the renal artery before it enters the parenchyma; (*b*) after having traversed the renal parenchyma in company with a branch of the renal artery, accompanying the perforating capsular branches of the interlobular arteries to their final distribution.

The specific nerves were found to arise from the renal plexus in one or two bundles on either aspect of the kidney. They are mostly medullated, the fibres being quite large, but non-medullated fibres are also present. After reaching the capsule they subdivide and radiate from the hilum in roughly fanwise manner. During the first part of their course they are usually found lying in relation with blood vessels, but

have no special association with them. They branch repeatedly, leave the blood vessels, and finally lose their medullary sheaths and become lost in the fibrous tissue of the capsule (see Figure III). No evidence of a nerve net was found, but, on the other hand, no actual endings were discovered, so that which type of end apparatus might have been disclosed by greater refinement in technique cannot be definitely stated. In any case, it is quite certain that the renal capsule has a specific nerve supply not connected with the innervation of its blood vessels.

As in Stöhr's investigation, no nerve supply could be found associated with the few fibres of plain muscle that exist in the renal capsule, which in fact were found only in a very few preparations. Though possibly a small proportion of the nerves found may have been destined for this purpose, their number is far too great for this to be their exclusive function. In view of the fact that there is no structure to which the great majority of them can conceivably constitute an efferent innervation, and, on account of their predominantly medullated nature, they are definitely afferent nerves.

It is mentioned by Kappis[29] that *nervi proprii* have not yet been found in the renal capsule of the dog. In the present investigation they were demonstrated in this situation on several occasions.

Physiology.

It is a well-known fact that patients suffering from nephritis have on occasion received definite benefit from the operation of decapsulation. The probable explanation for this has been given by experiments carried out by Hülse and Litzner,[30][31] who found by means of the stromuhr that after decapsulation a temporary improvement in blood flow through the kidney takes place, and similar findings have also been reported by Dogliotti and Mairano.[32] These experiments appear to support Stöhr's original suggestion that the specific nerve plexus of the renal capsule forms part of a nervous mechanism controlling the renal circulation. Still further support is lent by experiments carried out by Fischer.[33] Using the renal oncometer, he found that either electrical stimulation or mechanical stretching of the stripped capsule caused quite definite vasoconstriction of the kidney. On the very suggestive evidence of these experiments, it is considered, if not generally at all events by the workers themselves, that the capsular nervous plexus exists for the purpose of reflexly regulating the volume of blood flowing through the kidney, according to the degree of tension on the capsule.

These experiments, however, are not conclusive. A temporarily augmented blood flow through the kidney occurs not only after decapsulation, but also after simple mobilization,[34] when the continuity of the capsule is unbroken and the intraparenchymal tension is either normal, when the blood flow should remain the same, or increased, due to interference with the venous return, in which case the blood flow should diminish. This being so, a more likely explanation for the increased blood flow following decapsulation is a factor common to both opera-

tions, namely, a minor degree of trauma during the operative manipulations to the vaso-constrictor nerves of the renal pedicle, section of which is well known to cause vaso-dilatation.[35] Fischer's experiments at first might appear conclusive, but the fact must not be overlooked that stimulation of the central cut end of any sensory nerve, sciatic, intercostal, vagus or posterior nerve root,[35] or even ordinary acoustic stimulation,[36] causes vaso-constriction of the renal vessels and diminishes the number of glomeruli active at any one time.[37][38] Thus these experiments have demonstrated not a specific property of the capsular nerves, but a property of afferent nerves in general.

It is quite certain that the specific nerves of the capsule are not only afferent but sensory. Actual clinical proof of this has been obtained by Papin,[39] who in the course of renal operations under local anæsthesia observed that it was not till decapsulation had been carried out that the kidney became insensitive to mechanical stimuli, and that capsular pain can occur is conceded by Fischer[27] and also stated by Jungmann.[40] It is therefore not legitimate, on the evidence of increased blood flow which follows decapsulation, but is not directly due to it, and of the property of reflexly varying the degree of vaso-constriction of the renal vessels which the sensory nerves of the capsule possess not alone but in common with all other sensory nerves studied, to regard the reflex regulation of the renal circulation as the primary function of these nerves. It is far more reasonable to regard them as ordinary sensory nerves, concerned in the production of localized renal pain, of no more and no less importance in the regulation of renal circulation and secretion than other sensory nerves outside the urinary tract.

The nature of the pain caused by tension on the capsule requires some fuller comment, and in this connexion the existence therein of plain muscle is of interest. Its presence in appreciable amounts would tend to bring the capsule into the same category as the hollow muscular viscera, tension on whose walls produces pain which is referred to the corresponding segmental area of the body wall. Its amount, however, is quite inconsiderable and the cause of the pain appears rather to be tension on the fibrous capsule itself. Jungmann[40] states that the pain is referred. No indication as to whether or not this is the case can be obtained from anatomical study, so that the question can be decided on clinical evidence only. The pain, however, is apparently not necessarily referred to the musculature of the body wall. It is deeper seated, and unless complicated by other elements is not associated with muscular tenderness or rigidity, but frequently with tenderness of the kidney itself. Such being the case, it is at least a possibility that renal capsular pain is not referred, but local.

THE MECHANISM OF LOCALIZED RENAL PAIN.

The entire innervation of the renal parenchyma is distributed to the blood vessels and the cells of the tubules,[21][28] and it has been demonstrated clinically that it is quite insensitive to mechanical

stimuli.[39] Localized renal pain, therefore, arises as a result of stimulation by increased intrarenal tension of the afferent nerves of the pelvis and capsule. As in other organs, the severity of this pain is directly proportional to the rate at which the intrarenal tension is increased. With a rapid increase, as in hydronephrosis due to sudden complete obstruction, the pain is very severe, while if the tension is gradually increased over a period of months or years, as in cases of slowly growing tumour, polycystic kidney or very gradually developing hydronephrosis, the stimulation may be so slight that it is not recognized at all.

By a study of the mechanical changes brought about by various lesions of the kidney and pelvis, a fairly accurate conception can be obtained of the relative parts played in the production of localized renal pain by the pelvis and the capsule. In many cases the nerve endings in both situations are stimulated together, as in hydronephrosis due to obstructive lesions of the uretero-pelvic junction or upper part of the ureter. Here the increased intrapelvic tension will primarily give rise to a pain of pelvic origin. During the development of the hydronephrosis, however, there occurs a rise in intraparenchymal tension, sufficient to obstruct first the venous capillaries and later the glomerular circulation,[41] finally leading to atrophy of all but the largest arterial trunks.[42] This increased tension must be transmitted to the capsule, so that the pain of hydronephrosis is not only pelvic, but also capsular in nature, the capsular element necessarily accompanying any increase in intrapelvic tension, and often being further emphasized by the congestion which may follow acute obstruction or secondary infection. Similarly inflammatory conditions of the pelvis also probably give rise to some capsular pain as a result of the parenchymal congestion by which they are practically always accompanied.

Several conditions exist, however, in which the pain must be purely capsular. It is a well-known fact that removal or rapid disorganization of one kidney is frequently followed by an aching pain in the region of its healthy fellow.[43] The pain settles down in time and must be due to increased tension on the capsule while the process of compensatory hypertrophy is taking place. Where disorganization has proceeded slowly, or where there is little functioning tissue in the kidney removed, this pain is not a feature, the hypertrophy having taken place gradually over a long period of time. Again, bilateral lumbar pain frequently occurs in acute nephritis, when there is no question of increased intrapelvic tension. A unilateral aching pain may occur in cases of renal tumour, though its occurrence, on account of the frequent slow growth of such tumours, is not constant. This pain is quite distinct from the colic which may be caused by passage of blood clot down the ureter, and is probably of capsular origin. A similar inconstant pain may occur in cases of solitary renal cyst. Capsular pain may also be associated with inflammatory conditions of the kidney not associated with ureteral obstruction. Such are renal carbuncle and multiple cortical abscesses, which frequently occur in the presence of a sterile urine. Other

conditions such as renal tuberculosis or non-obstructive calculus formation may give rise to capsular pain as a result of parenchymal congestion. A further condition, very often symptomless, but quite frequently associated with localized renal pain, is nephroptosis. Here, if any ureteral obstruction exists or urinary drainage is bad, the pain will be in part of pelvic origin. But when no obstruction exists, the low position of the kidney is frequently responsible for unsatisfactory venous drainage, consequent parenchymal congestion and capsular pain.

Lastly, capsular pain is frequently due to perinephritis, not necessarily suppurative, but often fibrotic. This is usually secondary to inflammatory processes within the kidney, but is occasionally seen in the absence of any other demonstrable lesion of the urinary tract, and without obvious ætiology. This latter condition apparently corresponds to the "*nephritis dolorosa*" of German authors. Here there is no increased intrarenal tension, and the pain is apparently due to irritation of the capsular nerves by the fibrotic process. A second variety of pain may occur in the presence of perinephritis, not a true renal pain, but due to irritation of the last thoracic, ilio-hypogastric and ilio-inguinal nerves on which the kidney rests posteriorly, the pain being referred to the regions which these nerves supply.

Localized renal pain, therefore, in view of the nature of the lesions giving rise to it and of the alterations of intrarenal tension which they bring about, is in the great majority of instances either in whole or in part of capsular origin.

CONCLUSIONS.

1. The fibrous tissue of the renal capsule receives a specific afferent innervation composed of medullated and non-medullated nerves.

2. These nerves are concerned with the transmission to the central nervous system of impulses which result in the sensation of localized renal pain.

3. As with other sensory nerves, their stimulation also causes reflex alterations in the rate of blood flow through the kidney.

4. The sensation of localized renal pain is usually the result of increased intrarenal tension, but sometimes follows irritation of the capsular nerves by perinephritis.

5. The impulses producing the sensation originate both in the pelvis and the capsule, or in the capsule alone, according to the nature of the pathological condition producing them.

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THE CORPUS LUTEUM: A FURTHER INVESTIGATION.

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Our understanding of the functions of the endocrine system has developed largely as a result of our obtaining satisfactory biological methods of detecting the presence and activity of the various hormones. We need only to quote such substances as insulin, thyroxin, in the general medical field, and of particular interest to the obstetrician and gynæcologist, extracts of the posterior lobe of the pituitary gland, ovarian hormone, and most recently and of outstanding importance, the secretions of the anterior lobe of the pituitary gland.

The practical value of these methods or tests is of course obvious; first, as a means of detecting an overproduction, an under production or a dysfunction of the various endocrine organs—in other words, as a means to diagnosis based on a sound scientific basis; secondly, the rational application of the various hormones to our therapy of the disturbances of the internal secretory processes in the human being. Until we have a practical means of determining quantitatively the hormone content of an extract, our therapy must be largely empirical and often inaccurate. An over administration may be as harmful to the organism as an under administration is ineffective.

It was natural that such a macroscopically obvious structure as the *corpus luteum* with its periodical waxing and waning in size and its constant appearance in relation to pregnancy, should lead one to apply to it the function of an internal secretory organ.

Of the various functions attributed to the *corpus luteum* the most firmly established is that of producing a proliferation of the uterine mucosa specifically associated with the embedding of the fertilized ovum and with its early development.

The basis for our belief in the above function lies in the work of Fraenkel, Ancel and Bouin, Loeb, Hammond and Marshall and others. The thorough researches of Fraenkel, extending from 1903 to 1910, estab-

lished beyond doubt that the ovary, and in particular the *corpora lutea*, are essential to embedding of the ovum and its early development. He showed also that in the human female the *corpus luteum* reaches its highest development immediately before the beginning of menstruation, and that its degeneration coincides with the degeneration of the endometrium, that is, with the appearance of menstruation.

The work of the above-mentioned authors established the fact histologically that following ovulation and the formation of the *corpus luteum* in the rabbit, certain changes take place in the uterine mucosa which are seen as a much proliferated ramified glandular mucous membrane, the whole producing a very characteristic appearance. This proliferation occurs only in the presence of recently formed *corpora lutea*.

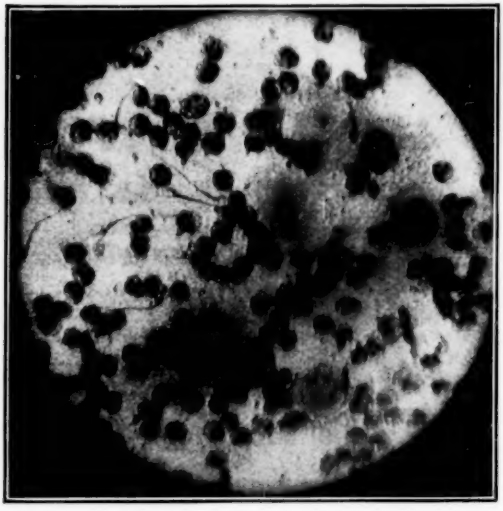

FIGURE I. Vaginal smear from rabbit immediately after copulation showing epithelium, leucocytes and spermatozoa.

In 1928 Corner and Allen carried out a series of experiments which confirmed the work of Fraenkel and other earlier authors and further developed a "test for the *corpus luteum* hormone," which in essentials is as follows.

An adult female rabbit, which has preferably been isolated for a month or more, is mated to a buck. Insemination is determined by examining vaginal smears for spermatozoa immediately after mating (see Figure I). About eighteen hours after mating, the rabbit is subjected to a bilateral removal of ovaries and a resection of the middle third of the left uterine cornu. This latter serves as a control. The rabbit is treated daily for five days with *corpus luteum* extract and killed one day after the final dose. The corresponding portion of the right uterine cornu is examined histologically and compared with the control section. The ovaries are sectioned as a routine and examined for recent *corpora lutea*. The usual picture seen is that of large ripe follicles—the result of the stimulation of copulation (see Figure II).

A positive result is indicated by a very characteristic ramified appearance of the endometrium (see Figures III and IV).

The validity of this test was recently confirmed by Clauberg, and the position of the *corpus luteum* further firmly established as an organ of internal secretion whose hormone has a specific activity on the

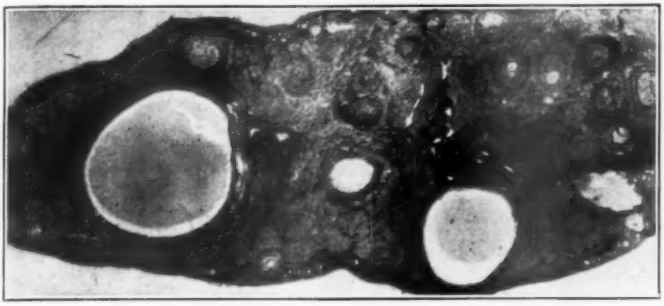

FIGURE II. Ovary of rabbit showing several primordial follicles and two large ripening follicles but no *corpora lutea*.

endometrium, producing a pregravid phase, identical with the premenstrual phase in the human female.

The test has been modified by Allen quite recently, he having shown that mating of the rabbit is not essential to the production of the pregravid state, provided that the animal is sexually mature. Further, the test can be carried out on immature rabbits which have been previously treated with œstrin (the hormone of the ripe Graafian follicle).

These two modifications indicate one essential factor, namely, that the uterus must first be brought under the influence of the hormone of the follicular fluid (œstrin) before the *corpus luteum* hormone can exert its effect. This we should expect from the natural sequence of events in the ovary, the

FIGURE III. A positive "Corner-Allen" test for the *corpus luteum* hormone: Control section of uterus (before treatment of rabbit with extract of *corpus luteum*).

ripening follicle with its accumulation of *liquor folliculi* always preceding the formation of the *corpus luteum*.

EXPERIMENTAL INVESTIGATIONS.

Employing the Corner and Allen test we have endeavoured during 1930 to detect the presence of the *corpus luteum* hormone in: (i) the blood and urine of the pregnant woman, and in human placenta; (ii) in the *corpus luteum* of (*a*) human, (*b*) sow, (*c*) rabbit; (iii) in a commercial preparation of extract of *corpus luteum* (Ciba, Basle). We shall consider these in detail.

Investigation of Blood and Urine During Pregnancy.

Procedure.

In all cases mature adult female rabbits were used. Two variations from the original Corner and Allen test were introduced. First, we

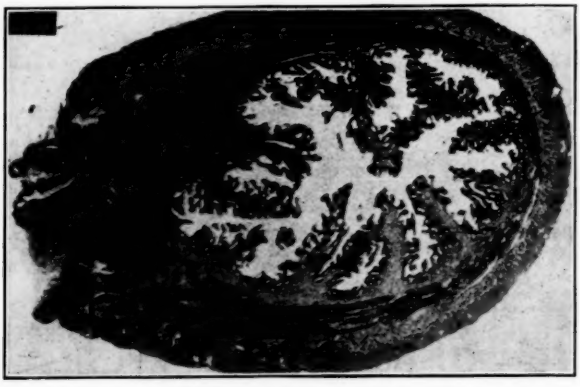

FIGURE IV. A positive "Corner-Allen" test for the *corpus luteum* hormone: After five days' treatment with a potent extract of *corpus luteum*.

varied the time interval after copulation at which the rabbit was subjected to operation. As Allen points out that mating is really unnecessary, the time factor makes no difference. We mated the animals and examined vaginal smears for spermatozoa in order to be certain of the animals' maturity. The second variation was in the duration of the treatment. As the concentration of *corpus luteum* hormone in blood and urine would be unlikely to be equal to that of an extract, we varied the period of duration of treatment in different animals. In some cases we proceeded as follows. After seven days' treatment the rabbit was subjected for the second time to operation, and the middle third of the right uterine cornu was removed. The abdomen was then closed and the animal was allowed to live another six or seven days; it was

then killed and the remainder of the uterus was removed and examined. In some animals the treatment was continued up to the death of the rabbit, in others it ceased at the time of the second operation (that is, after seven days). In this latter series we had additional controls, and were able to study the possibility of a delayed effect of treatment. At autopsy, of course, the ovarian sites were most carefully examined for any ovarian rests.

Blood of Pregnant Women.

Eight women were examined. The blood came in four instances from normal women at the end of pregnancy and in four from women in the second to the fourth month. This we considered an important point, as there is a good deal of reason to believe that the maximum activity of the *corpus luteum* occurs during the earlier part of pregnancy, that after the first few months the placenta possibly takes over largely the function of the *corpus luteum*, resulting in a gradually diminishing importance of the latter. It is even considered by some authorities that the termination of a normal pregnancy depends on the degeneration of the *corpus luteum*. In every case the blood was citrated and injected intraperitoneally. For details of dosage *et cetera*, see protocol.

FIGURE V. Illustrating the muscular hypertrophy of rabbit's uterus after treatment with urine from a pregnant woman. The hypertrophy is the result of the œstrin contained in the pregnant urine. The control.

In one case only, that in which the blood of a woman at term was used, did we obtain a very slight degree of proliferation. In one instance in which blood from a woman two months pregnant was used, the uterine muscle was much hypertrophied. In all other cases no proliferation occurred. One animal was treated in a similar way with blood from a patient with a *corpus luteum* cyst. No proliferation occurred.

Urine of Pregnant Women.

The same procedure was adopted with urine from pregnant women, except that the animals were treated with intraperitoneal injections of urine. Six women were examined. Three were at term and three had gestations of two months.

In one case—that of a two months' gestation—we obtained a mildly positive result.

In all cases the general enlargement of the uterus was marked and the hypertrophy of the uterine muscle in some cases striking (see Figures

V and VI). This was certainly due to the follicular hormone (œstrin), which we know to be excreted in the urine during pregnancy and for which we have a specific test in the castrated mouse (Allen and Doisy).

This muscular hypertrophy and general uterine growth were found also by Clauberg in rabbits treated with folliculin.

Human Placenta.

In one animal a piece of human placenta weighing ten grammes was implanted intramuscularly in the dorsal region and the rabbit killed after eight days.

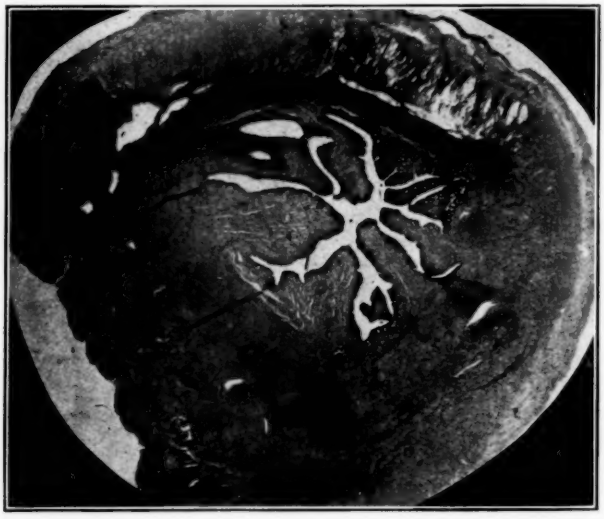

FIGURE VI. Illustrating the muscular hypertrophy of rabbit's uterus after treatment with urine from a pregnant woman. The hypertrophy is the result of the œstrin contained in the pregnant urine. After treatment.

There was some increase in the uterine glands and hypertrophy of muscle, but no proliferation of the endometrium.

Corpora Lutea Implantation.

Sow's Corpora Lutea.

An adult female rabbit was taken and the usual procedure carried out, except that at the time of removal of ovaries and control portion of uterus, six fresh sows' *corpora lutea* were implanted intramuscularly in the flanks. The animal was killed after six days.

A slight degree of proliferation resulted.

At this stage the recent work of Allen appeared to which we have already referred, and in which he demonstrated the practicability of using immature rabbits. We therefore took three immature rabbits, weighing 1,150 grammes, 1,220 grammes and 1,270 grammes respectively, and subjected them to preliminary treatment with œstrin (for details see protocol). The removal of ovaries and control portion of uterus was then proceeded with as usual, and the subcutaneous implantation of *corpora lutea* carried out.

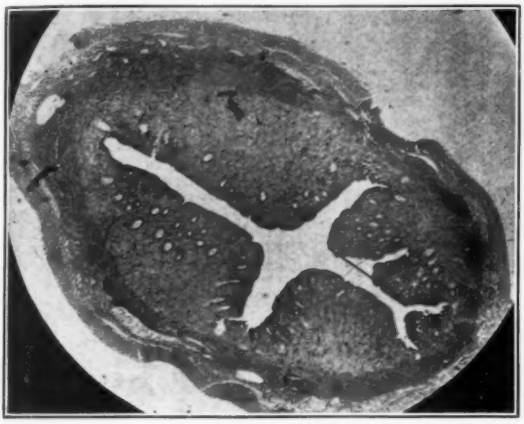

FIGURE VIII. Infantile rabbit's uterus showing a small amount of proliferation of endometrium following implantation of rabbit's *corpora lutea*. The control.

Human Corpora Lutea.

Fresh human *corpus luteum*, removed at operation for interruption of pregnancy by abdominal hysterotomy, was used in two cases. In both cases no proliferation resulted.

Rabbit's Corpora Lutea.

Fresh rabbit's *corpora lutea*, removed from pregnant rabbit, were used. A mildly positive result was obtained (see Figures VII and VIII).

This result is interesting, as, although the actual size of luteal tissue in these *corpora lutea* is very much smaller than in those of the human being and sow, yet a mildly positive result was obtained. The question of specificity of tissue is an interesting speculation.

FIGURE VIII. Infantile rabbit's uterus showing a small amount of proliferation of endometrium following implantation of rabbit's *corpora lutea*. After implantation.

Corpus Luteum Extract.

We were very kindly furnished with an extract of *corpus luteum* by the "Ciba" Manufacturing Company, Basle.

Nine animals were employed in our investigations of this extract, none of which returned positive results. In seven cases the extract had been stored for six or more weeks and in the other two cases the

preparation had been sterilized by heating. The absence of positive results is of practical importance. The rapid degeneration of the *corpus luteum* hormone when kept in an oily solution has already been pointed out by Allen, who found in some cases that the hormone had disappeared in one week after preparation. Preparations stored in absolute alcohol are preserved for many months. On the other hand, in Allen's experience the hormone is relatively thermostable. The protocol appears at the end of the article and contains all particulars as to the various experiments.

DISCUSSION.

Our chief object has been to demonstrate by the Corner-Allen test the presence of the *corpus luteum* hormone in the blood and urine of the female during pregnancy. The steps of the test are shown diagrammatically in Figure IX.

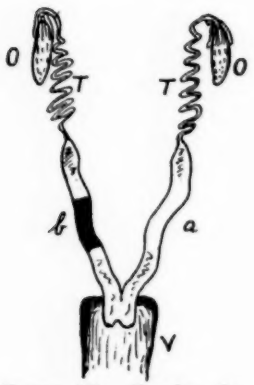

FIGURE IX. Showing the steps of the Corner-Allen test. a = middle third of left uterine cornu (control portion removed with ovaries before treatment); b = middle third of right uterine cornu (removed after treatment); O = ovary; T = tube; V = vagina.

Our results would lead us to conclude that the hormone was not present. But this result must be interpreted in correlation with a consideration of the question of delicacy and applicability of the test.

There is no question as to the important rôle the *corpus luteum* hormone plays in the female genital history, and from its nature as a hormone we should expect to find evidence of its presence in one of these body fluids. Relatively large quantities of blood and urine were injected. The anterior pituitary hormone content of these fluids is enormous (10,000 mouse units per litre of urine), and the ovarian hormone (œstrin) content is also very large. That the *corpus luteum* hormone is absent from the same fluids seems to us an unjustifiable conclusion and we are forced to a criticism of the delicacy of the test.

It is possible that by using larger quantities or by a concentration of the blood and urine, a different answer may be obtained.

It is interesting here to note that Corner and Allen were unable to elicit a positive result from extracts of placenta and follicular fluid. The question of antagonism between the two hormones (œstrin and *corpus luteum*), as suggested by Seitz in 1914, may also be considered in relation to our results from blood and urine.

If the delicacy of the test were in any way comparable to that of the Zondek-Aschheim test in the case of the anterior pituitary hormone, we should have a valuable laboratory means of estimating to what extent the *corpus luteum* was at fault as an organ of internal secretion in such conditions as disturbances of the menstrual cycle, in those cases of repeated premature birth or abortion in which a definite pathological

TABLE SHOWING PROTOCOLS OF EXPERIMENTS.

No.	Examination of Vaginal Smear for Spermatozoa.	Time of First Operation.	Substance Used. Amount and Duration of Treatment.	Time of Second Operation.	Animal Killed.	Results and Remarks.
1	+	1 hour after copulation.	*Corpus luteum* extract (1) 8·5 cubic centimetres over 15 days.	After 8 days.	After 15 days.	No proliferation.
2	+	18 hours after copulation.	*Corpus luteum* extract (1) 5 cubic centimetres over 7 days.	After 7 days.	After 13 days.	No proliferation.
3	+	5½ hours after copulation.	*Corpus luteum* extract (1) 4·5 cubic centimetres over 7 days.	After 7 days.	After 13 days.	General enlargement of uterus muscle and sub-mucous tissue. No proliferation.
4	+	15½ hours after copulation.	*Corpus luteum* extract (1) 7·5 cubic centimetres over 13 days.	After 7 days.	After 13 days.	? Slight proliferation Hypertrophy of muscle.
5	+	15 minutes after copulation.	*Corpus luteum* extract (1) 7·5 cubic centimetres over 13 days.	After 7 days.	After 13 days.	No proliferation.
6	+	1½ hours after copulation.	*Corpus luteum* extract (2) 4·5 cubic centimetres over 6 days.	After 6 days.	After 11 days.	No proliferation. Atrophy of uterine glands.
7	+	6½ hours after copulation.	*Corpus luteum* extract (2) 7·2 cubic centimetres over 12 days.	After 6 days.	After 12 days.	No proliferation.
8	Spermatozoa not found, but copulation observed.	24 hours after copulation.	*Corpus luteum* extract (3) 11·8 cubic centimetres over 5 days.		After 6 days.	Many cystic enlargements of uterine glands. No proliferation.

TABLE SHOWING PROTOCOLS OF EXPERIMENTS (*Continued*).

No.	Examination of Vaginal Smear for Spermatozoa.	Time of First Operation.	Substance Used. Amount and Duration of Treatment.	Time of Second Operation.	Animal Killed.	Results and Remarks.
9	+	23 hours after copulation.	*Corpus luteum* extract (3) 23·8 cubic centimetres over 6 days.		After 6 days.	Marked hypertrophy of muscle and submucous tissue. No proliferation.
13	+	1½ hours after copulation.	Implantation intramuscularly of six fresh *corpora lutea* (sow).		After 6 days.	Slight degree of proliferation.
14	+	23¾ hours after copulation.	Implantation intramuscularly of human placenta (weight 10–12 grammes).		After 8 days.	Some increase in uterine glands. Some hypertrophy of muscle. No proliferation.
15	+	1½ hours after copulation.	Subcutaneous and intraperitoneal injection of citrated pregnant blood. 25·7 cubic centimetres over 13 days. (Blood—patient at term.)	After 8 days.	After 14 days.	No proliferation.
16	+	1½ hours after copulation.	Intraperitoneal injection of citrated pregnant blood. (Patient at term.) 14 cubic centimetres over 7 days.	After 7 days.	After 12 days.	Very slight degree of proliferation.
17	+	18 hours after copulation.	Intraperitoneal injection of citrated pregnant blood. (Patient at term.) 29 cubic centimetres over 12 days.	After 7 days.	After 12 days.	No proliferation.
18	+	1 hour after copulation.	Citrated pregnant blood—term. 30 cubic centimetres over 12 days.	After 7 days.	After 13 days.	No proliferation.
19	Not found.	5 hours after copulation.	Serum—pregnant 4 months. 12 cubic centimetres over 6 days.	After 7 days.	After 13 days.	No proliferation.

TABLE SHOWING PROTOCOLS OF EXPERIMENTS (*Continued*).

No.	Examination of Vaginal Smear for Spermatozoa.	Time of First Operation.	Substance Used. Amount and Duration of Treatment.	Time of Second Operation.	Animal Killed.	Results and Remarks.
20	+	1 hour after copulation.	Pregnant blood—3 months. 18 cubic centimetres over 7 days.	After 7 days.	After 13 days.	No proliferation.
21	Not found.	24 hours after copulation.	Pregnant blood—2 months. 33 cubic centimetres over 5 days.		After 7 days.	No proliferation.
22	+	24 hours after copulation.	Pregnant blood—2 months. 39 cubic centimetres over 5 days.		After 6 days.	No proliferation. Muscle hypertrophy.
23	+	3 hours after copulation.	Blood from case of *corpus luteum* cyst. 14 cubic centimetres over 5 days.		After 6 days.	No proliferation.
24	+	1¼ hours after copulation.	Pregnant urine—term. 20 cubic centimetres over 13 days.	After 7 days.	After 13 days.	Considerable hypertrophy of muscle. No proliferation.
25	+	21 hours after copulation.	Pregnant urine—term. 19 cubic centimetres over 12 days.	After 7 days.	After 13 days.	General enlargement of uterus, particularly of muscle. No proliferation.
26	+	4½ hours after copulation.	Pregnant urine—term. 9 cubic centimetres over 7 days.	After 7 days.	After 13 days.	No proliferation.
27	+	24 hours after copulation.	Pregnant urine—2 months. 45 cubic centimetres over 5 days.		After 13 days.	Control proliferation. Result, no proliferation. Ovaries: several recent *corpora lutea*.

TABLE SHOWING PROTOCOLS OF EXPERIMENTS (*Continued*).

No.	Examination of Vaginal Smear for Spermatozoa.	Time of First Operation.	Substance Used. Amount and Duration of Treatment.	Time of Second Operation.	Animal Killed.	Results and Remarks.
28	Not found.	24 hours after copulation.	Pregnant urine—2 months. 82 cubic centimetres over 6 days.		After 7 days.	No proliferation.
29	Not found.	22 hours after copulation.	Pregnant urine—2 months.			In places mildly positive.

No.	Details of Experiment.	Result and Remarks.
10	*Infantile female rabbit* (1,150 G.). (i) Treated for 6 days with 300 rat units of "Folliculin." (ii) Operation after 6 days. (iii) Treated with *corpus luteum* extract (3) 18 cubic centimetres over 5 days. Animal killed on sixth day. Operation consisted of bilateral oophorectomy—resection of portion of left uterine cornu. Subcutaneous implantation of *corpora lutea* from pregnant rabbit.	Mildly positive.
11	*Infantile female rabbit* (1,220 G.). (i) Treated for 3 days with boiled pregnant urine 30 cubic centimetres. (ii) Operation after 3 days. Subcutaneous implantation of one fresh human *corpus luteum*. Animal died on third day after operation.	No proliferation.
12	*Infantile female rabbit* (1,270 G.). (i) Treated for 3 days with boiled pregnant urine 30 cubic centimetres. (ii) Operation after 3 days. Subcutaneous implantation of one fresh human *corpus luteum*. Animal killed after 7 days.	No proliferation.

reason for such occurrences cannot be found, and the relation of the ovarian hormone to myomata, as suggested by Seitz, would be capable of further investigation.

The dependence of many cases of so-called endometritis on a *corpus luteum* hormone irregularity would be another interesting field.

Two recent attempts to find a more practicable test for the *corpus luteum* hormone are those of Clauberg using histological changes in uterus and vagina of the mouse as a criterion, and of Siebke who has produced a considerable lengthening of the period of gestation in the rat by treatment with extract of *corpus luteum*. Further work must show whether these represent an improvement on the original Corner-Allen test.

SUMMARY.

1. Using the Corner-Allen test we have been unable definitely to detect the *corpus luteum* hormone in the blood and urine of the pregnant woman.

2. Similarly when human placenta was used a negative result was obtained.

3. Using a modification of the test in the employment of immature rabbits, we obtained no proliferation of uterine mucosa after implantation of human *corpora lutea*, and a mildly positive result with the *corpora lutea* of the rabbit and sow.

4. An extract of *corpus luteum* gave a negative result. The question of vitality of the hormone, as affected by storage and by heat sterilization, is discussed.

5. A criticism of the test as a practical means of estimating the behaviour of the *corpus luteum* hormone in the body is offered.

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SOME PROBLEMS IN STRABISMUS.

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So often in medicine the obvious is not the fundamental. Squint, like the deformities of spine and limbs, is an obvious outward sign. Less obvious issues, however, require attention before one tackles the deformity, and if rest be the essential for spinal disease, exercise is certainly all important for strabismus. The fundamental problems in strabismus are the loss of useful vision of one eye resulting in amblyopia and the loss of perception of depth and distance and the other features of stereoscopic vision which result from the ability to use both eyes together.

AMBLYOPIA.

> *Doctor* (of Lady Macbeth walking in her sleep): You see, her eyes are open.
> *Gentlewoman*: Ay, but their sense is shut.—MACBETH, V, 1.

The difference between amblyopia and amaurosis, according to a certain professor, was that in the former both the patient and the physician could see nothing, while in the latter the patient could see a little. The "not seeing" of the physician may have initiated a "not doing" policy, for certainly much amblyopia, whether due to the neglect of the brain or not, remains and even increases because of the neglect of the physician. More probably the doctrine of Schweigger (1871), that amblyopia was congenital and the cause of strabismus, produced neglect by abolishing any incentive for the physician to treat amblyopia.

Some retinal lesion, for example, a hæmorrhage at birth, was postulated as the primary cause. Such an effusion can disappear completely, but those that are macular can do irreparable damage first. It was well known that obvious ocular defects, such as refractive anomalies, opacities in the media and fundus defects, are often associated with convergence.

Congenital amblyopia rarely occurs apart from squint [Worth (1929), Maddox], and when it does occur it is rarely unilateral, and Maddox considered it to be cerebral in origin. In 15% of 193 children with recent squint, Worth found the amblyopia to be congenital. The vision was never less than $^{6}/_{60}$. A central scotoma was never found, and the fusion faculty was well developed. In these respects it differs from the amblyopia of strabismus.

Though the occasional failure of early and thorough training of amblyopic eyes conforms with the idea of a congenital origin, yet the

frequency with which success meets such educative treatment proves that in the majority another agent is at work. For a time the older theory of neglect, advocated by von Graefe and Donders, became less popular, but it appears that more recent observations enable us again to consider the amblyopia to be the result rather than the cause of strabismus. If this defect is rarely congenital, can it be acquired and even be the result of the strabismus rather than the cause?

Let us consider the forms of acquired amblyopia known to us. In the hysterical form a withdrawal of attention appears to be the cause. The vision is lost suddenly during profound emotion. Compare with this the complete though practised suppression of vision in microscopists and watchmakers. In them withdrawal of attention appears to be voluntary at first and later unconscious, and it produces a psychic loss of vision.

Amblyopia due to suppression does occur, and is seen in the following instances in which dissimilarity, non-use and diplopia appear as exciting agents. We know that binocular vision demands the fusion of two almost identical images, and conversely that dissimilarity prevents fusion. In anisometropia, repression of one image may occur by the confused cortex, and may lead to amblyopia. The blurred image due to astigmatism may cause an interesting form of amblyopia. Martin (1890) found that the retinal meridian in which the diffusion was greatest in an astigmatic eye, had only one-half or one-third the acuity that the meridian of least diffusion had. He found meridional amblyopia most frequently in eyes in which no attempt was made to neutralize the astigmatism by accommodation, and Gonin found it most marked in patients who complained least of asthenopic symptoms.

We know that both strabismus and amblyopia can follow neglect of one eye. After bandaging one eye, after prolonged blepharospasm, and after corneal inflammation or lenticular wounds, amblyopia may appear. In 1855 von Graefe reported a child who, after eleven months of blepharospasm, was unable to see anything but a bright light. Normal vision, however, returned after three months. In congenital cataract arrested development from non-use of the eye may produce amblyopia. Juler (1921) has shown that after operation for cataract produced by injury before the age of five, not one child amongst five developed vision of more than "fingers at two metres" during the following four to nine years, while all except three of thirteen children injured during the second decade developed at least $^{6}/_{12}$ vision partly. Probably similar experience produced the dictum of Fuchs: operate early in congenital cataract to prevent amblyopia.

A further form of amblyopia appears in patients with obstetric palsies. Gifford (1926), who studied a series of such cases, considered that the amblyopia was due to repression because diplopia caused cortical confusion.

The toxic forms of amblyopia need not be considered, for in them microscopical degeneration is found. Structural change in the amblyopia

of strabismus is not found unless Seefelder's and Wolfrum's finding (1914) of incompletely developed maculæ is confirmed. Does the amblyopia of strabismus correspond to one of these established forms? It is of interest to note, as will be shown later, that the only factor common to all cases of convergent strabismus is a more or less defective ability to fuse. This prevents binocular vision and produces diplopia. Can the subsequent cortical confusion cause suppression? If so, the resulting amblyopia is similar to that due to dissimilarity, to neglect and to diplopia.

Let us consider briefly the nature of the amblyopia in strabismus, and then let us consider the evidence which supports the conception of its acquired origin.

The Nature of the Amblyopia.

The amblyopia of strabismus is always associated with a relative (Peter) or absolute central scotoma (Worth). The average vision has been found to be $^{6}/_{22}$ (Evans, Heine) and $^{6}/_{18}$ (Peter). Percival considered the light sense normal, and Barrie (1923) found that colour vision was less affected than one would expect. With vision up to $^{5}/_{30}$ the detection of colour was practically normal; below this green was not seen. The scotoma is usually from 2° to 5° in diameter, with an extension towards the blind spot and an angioscotomatous extension from this spot towards it [Peter (1929), Evans (1929)]. In passing, let it be noticed that Best demonstrated in the temporary amblyopia during microscopy an absolute central scotoma of the same size as this and normal perception in the adjacent periphery [F. Best (1906)]. Most observers consider that the peripheral field is depressed [Peter (1929)], though Worth found it to be normal.

Incidence of Amblyopia.

It can be shown that amblyopia occurs most frequently, most rapidly, and most completely in eyes which squint most early. The influence of age is shown by the universal finding that amblyopia is rare if squint develops after seven. Priestley Smith (1898) found it to be much more common amongst those who developed squint during the first three years of life than afterwards. The earlier the onset of squint, the more rapidly can central fixation be lost. The time taken for this to occur equals approximately one-third of the age at time of onset of the squint. Worth found central fixation lost frequently eight or ten weeks after a convergence commencing between six to eight months. Usually it took over five or six months if the squint developed about the age of eighteen months, over a year if the onset was about the age of three years, and it is not lost at all if the onset is delayed till the age of six.

From Worth's statistics concerning 787 cases of constant unilateral convergent strabismus, it can be shown that of children who developed a squint during the first year of life, and who had squinted for less than

one-eighth of their lives, 89% had $^6/_6$ vision and none less than $^6/_{24}$ in the good eye: while amongst those who had squinted for more half their lives, none had $^6/_6$, 89% had less than $^6/_{60}$, and 45% had lost central fixation. Regardless of the year of onset, it was found that of those who had squinted for less than one-eighth of their lives, 85% had $^6/_6$ vision, and none less than $^6/_{60}$, and of those who had squinted for more than one-eighth but less than one-half of their lives, 39% had $^6/_6$ vision and 6% had less than $^6/_{60}$, and of those who had squinted for more than half their lives none had $^6/_6$ and 61% had less than $^6/_{60}$.

Amblyopia is more apt to occur in convergent than in divergent strabismus. It is significant that the latter variety develops later as a rule than the former. Schnabel (1899) found vision reduced to less than 0·1 in 35% of convergent and in only 11% of divergent squints. Once the period of development of macular and binocular vision is over, suppression is less apt to occur. Similarly, though amblyopia appears in congenital cataract and obstetric palsies, it does not follow the development of these conditions in maturity. A functional or acquired amblyopia can arise from disuse only during the first few years of life.

The period of opportunity is during the development of macular and of binocular vision. The former is considered to take four years, and the latter six. Flechsig found that the sensory fibres of the primary optic radiations were myelinated at birth, the motor at birth or soon after, whilst the myelination of the association fibres developed later still. Bolton has shown that the pyramidal layer of the visual cortex is not more than one-half of its proper depth at birth. The immaturity of the brain at birth made necessary by its mass must not be forgotten. Even the visual cortex of a dog is unexcitable till the fortieth day, at which time it can follow a moving object.

Why do only certain squinting eyes become amblyopic? The age of onset gives a partial answer to this question. Anisometropia may also play a part. Further explanation comes from the fact that some convergent eyes are used for fixation, when the position of the object to be looked at corresponds to the direction of the squinting eye. This prevents complete neglect. It would be interesting to know whether amblyopia is most common in the most marked squints, because there is then complete neglect, or is least common in these eyes because the images are so far apart as to cause little confusion and so less need for exclusion.

The amblyopia only occurs in unilateral strabismus, never in alternating strabismus. What are the essential differences between these forms of strabismus? It is of interest to observe that the alternating variety develops earlier than the unilateral group. Does age determine here also the development of amblyopia? Worth found that only one in eight of 1,017 unilateral convergent squints appeared during the first year of life, whilst one in three of 178 alternating squints developed in this period. He also found that the average age of onset of thirty-three alternating convergent "squinters" with a refraction of less than 1·0

diopter spherical (lowest meridian of right eye) was eleven months, while the average of eighty-three with unilateral convergence with a similar refraction in the fixing eye, was two years and ten months.

Another feature which distinguishes alternating and unilateral convergent strabismus is the relatively small refractive error in the former. Of patients with unilateral strabismus 16·7% and of patients with alternating strabismus 29% had hypermetropia of two diopters or less: 6% of the former group and 14·5% of the latter had one diopter or less of hypermetropia. Worth also found anisometropia in 68% of unilateral and in only 43% of alternating convergent squinting children. Astigmatism of over 0·5 diopter was found approximately as often in the fixing eye in unilateral strabismus as in the average of the two eyes in alternating strabismus (38·5% and 39%), but it was considerably more common in the deviating eye in the former group (54%). In true alternating strabismus there is no fusion sense. Amblyopia has been found to develop soon after an alternating strabismus becomes unilateral (Sachs, 1899). If an undeveloped fusion faculty is the main cause of the majority of convergent eyes, it is not surprising that the earliest form to appear—alternating strabismus—occurs in children who have no fusion sense at all. The unilateral form which appears later, is usually accompanied by some power to fuse. If the amblyopia was congenital, one would expect this type to develop as early as the alternating variety. These observations suggest that it is neither the early onset, the absent fusion sense, nor the low ametropia that prevents amblyopia from developing, but simply the fact that both eyes are used.

It may be asked: "Why in the absence of anisometropia do some squints remain alternating and others become unilateral?" Preference is probably given to one eye because of some individual variation in the factors which determine the relative positions of the eyes.

The marked reduction of visual acuity suggests active suppression rather than simply a loss from neglect. An amblyopia "*ex diplopia*" causing dysopia is suggested rather than "*ex anopsia*." Too much or too many are seen rather than too little (Maddox). The vision may be only "counting fingers" and central vision out to 20° may be only perception of light. This represents a reduction much below even peripheral vision, and the visual acuity of the macula at the end of the first few weeks of life. It is considerably worse than the vision found in congenital amblyopia, which is never less than $^{6}/_{60}$, which is normal vision at 50° from central fixation. As long as a macular image from the convergent eye reaches consciousness, confusion will exist, and central vision will be the earliest and the most thoroughly excluded. Not only must the superior acuity of this area go, but it must become inferior to that of adjacent parts. The macula of this eye becomes neglected, for the images it receives are not of objects studied by the fixing eye and by the brain. Central fixation becomes unsteady and the image appears to tremble and later it is superseded by eccentric fixation. Diplopia results because the image of an object being fixed,

is formed in the squinting eye at some distance from the macula and, being projected in relationship to the macula, produces a faint eccentric false image. An effort is probably made to remove the macula, the centre of orientation that determines this false projection. The more immature the development of the macula and its central connexions at the time of onset of the squint, that is, the younger the child, the quicker and more marked will be the effects of neglect and suppression. In infancy, whether the suppression is an attempt to evade diplopia or not, it appears to be a purposive action and not simply the result of non-use.

Suppression of impulses is a constant and normal action. "Of the innumerable stimuli which shower in on the individual at any given moment, most are suppressed" or fail to occupy "the focus of the field of consciousness" (Parsons). If they conflict with those selected for concentration, they are suppressed; if they can serve a useful purpose, they form a vague impression in the periphery of the field of consciousness. Frequently "the art of living was the art of omitting." "Such elements of protopathic sensation as are serviceable are utilized when the later and higher forms of sensibility come into existence. It is only those features of early sensibility which are incompatible with later development which are suppressed." The suppression at the macula of certain features, for example, diffuseness of the primitive protopathic light sense, permitted the development of more exact discrimination. Suppression of one eye at a time probably occurs in animals with panoramic vision. Later "when perfect binocular vision was evolved, the eyes were placed so that suppression of all impressions of one eye became unnecessary." Rivalry between different points of each visual field increased. Then the suppression, whether complete or not, of disparate points alone remained necessary. Parsons considers that the suppression in strabismus may be a regression—a return to the suppression associated with panoramic vision. Binocular fusion is phylogenically a late adaptation and therefore reversion is relatively easy. For this reason and on account of its early onset, Parsons considers that hypnosis would fail to restore vision in strabismus.

The confusion caused by diplopia is well known. Probably the infant has two courses open. He can either see singly and indistinctly, or distinctly and double. Distinct vision is essential, so diplopia develops. He cannot learn to fuse the two images, for his fusion sense is too immature and the images too far apart. Fortunately he has the power to exclude one image from consciousness. It is difficult to disregard double images when adjacent, so suppression can be aided by an increased deviation. This is usually in a horizontal direction, but at times an upward deviation is seen. It is easier then for the patient to disregard the second image. The patient may also keep the two images at the same distance apart to help suppression and so the very concomitance is an aid. The area of retina used for eccentric fixation varies. The extent of the suppression is the most important factor in determining this.

Those patients with a small scotoma appear to use a paracentral area at the edge of the scotoma for fixation. As the blind area extends and the paracentral area is included in the scotoma, a more nasal area will be used until at last best vision is obtained by turning the eye in further and fixing with the extreme nasal periphery of the retina.

The periphery of the temporal field escapes suppression because as a rule it is not overlapped by the field of the other eye, and because it is used for objects hidden by the nose from the other eye. Therefore, the images of objects in this area do not cause troublesome rivalry requiring suppression. Another factor tends to preserve vision in this area in some instances of strabismus of early onset and fixed degree. The desire for binocular vision may lead to an attempt to establish such vision. The result may enable the patient to pass Hering's drop-test—an inexact test of binocular vision (Worth). This development has led to the description of a "false macula" or "pseudo fovea." These are misleading terms, for no specialization of structure occurs. The continued use of certain cells and fibres has simply led to better interpretation. Worth states that the vision of this area is never greater than the normal acuity of the part used, that is $^{3}/_{60}$ [perception of fingers at four metres (Asher)]. This area replaces the macula as the centre of orientation of the squinting eye. A similar area may dominate visual direction in hemianopia. The brain learns to project objects in accordance with the straight eye. The eccentric image formed at the retinal area which is opposite the object when fixed by the other eye, that is, at the false macula, is projected in the same direction as the image from the other macula. This means the development of new corresponding points—a new field. A marked though transient crossed diplopia may develop when such an eye is put straight by operation. As diplopia is due to the formation of two images of the same object, and as the false macula is no longer opposite the object looked at, this area can take no part in the production of the diplopia. The image at the macula of the operated eye is projected as formerly, according to the distance from the false macula, and so diplopia results. It follows then that projection, a cerebral action, is false and not that structure is altered and a new macula formed. Recently I have examined a man, aged forty-six, who has squinted all his life, and has now developed a cataract in the fixing eye. With glasses central fixation of the squinting eye enables $^{6}/_{60}$ to be read, and when he fixes with his nasal retina he reads $^{4}/_{60}$. Two questions are suggested by this. Should one be able to demonstrate uniocular diplopia in this eye, and should one be able by perimetry to show a field of vision with two sensory gradients, two areas of extra acuity? Though a patient of Bielschowsky, who was recovering vision in a similar eye after injury to the good eye, was conscious of two images of the lamp during direct ophthalmoscopy, I cannot develop diplopia or demonstrate two sensory gradients in testing my patient. Bielschowsky's patient considered the image of the false macula the correct one, and that at the true macula the false one.

It is interesting to refer briefly to a condition described by Bielschowsky, in which with integrity of the afferent and the receptor systems, stereognosis is absent. The condition is one of paralysis which is congenital or which arises during the first few years of life. If the hand in question is compelled to touch, the touch paralysis—incapacity to recognize form—disappears within a few days or at most weeks, but the touch "engrams" now obtained remain labile for a long time; that is, they are soon lost again if the hand is not compelled to touch continuously. This state is in marked contrast to the stability of the astereognosis due to organic disease of the post-central convolutions or their afferent paths, which can only be improved slightly, if at all. The touch "engrams" are acquired normally during the first two or three years of life, and remain fixed from then on. No hemiplegia appearing after the third year can produce an astereognosis, provided that the afferent system is intact. This "*astereognosis absente usu manus*" may throw light on the conception of *amblyopia ex anopsia*.

The previous evidence supports the theory of acquired amblyopia, because it shows that amblyopia can be produced. Further evidence is supplied by the fact that it is possible to remove amblyopia and restore vision. This would be unlikely if such blindness were congenital in origin. Sherrington's researches show that not only does the resistance offered by the synapses to impulses vary, making way for some and obstructing those that are antagonistic (in diplopia), but that the progress of repeated similar stimuli is facilitated.

It is well known that during the first five years of life not only the strabismus, but also the amblyopia, can be transferred from one eye to the other by occlusion. This appears to me to be the most valuable evidence supporting the theory of an acquired origin for amblyopia. Worth refers to one child who had one eye atropinized for four or five months, and the strabismus and amblyopia became transferred. One relies on transference of strabismus in the routine treatment of all unilateral strabismus. It is also well known that vision gained by occlusion may relapse if the fixing eye is given a temporary advantage (Worth). Sattler had similar experiences.

The most rapid improvement following occlusion occurs in the most recent cases. Many children with eccentric fixation lose it; others develop slightly greater eccentric acuity, but never more than 0·1 (Sattler, 1927). Peter, as a result of intensive training, obtains $^6/_6$ and $^6/_5$ vision in the majority of children up to seven and in many of those up to ten years of age. He reported sixteen consecutive private patients, average age thirteen years, with average corrected vision of $^6/_{40}$, all with a central scotoma, who, after training, developed average vision of $^6/_{6\cdot8}$.

It appears that if other things—muscle balance, intellect and fusion faculty—are equal, time is the factor which causes the difference between normal eyes that squint and see and those that do not see. Worth has written that in the majority of cases, if the squint has not lasted constantly for more than half the child's life, full normal vision can be

secured. Bielschowsky reported a child, aged seven, with vertical strabismus, whose vision failed to $^1/_{15}$ within a year, and on occlusion improved to $^1/_4$ in a few weeks. Unfortunately, it is rarely possible to carry out prolonged treatment by occlusion in older children and adults, and this may be one reason why amblyopia disappears less frequently in them. Complete and prolonged occlusion of the macula of the good eye is the essential, as is seen by the following cases of spontaneous recovery. In them recovery occurred only if the other eye was removed or a central scotoma or complete cataract developed.

Many observers have reported examples of spontaneous recovery from the amblyopia of strabismus after loss of the good eye. Peter (1929) recently reported two patients with such recovery, who had been amblyopic for fifty or sixty years. Schaff (1923) had a patient, aged fourteen, who, three months after losing one eye, recovered from $^1/_{10}$ to $^6/_6$ vision in the amblyopic eye. Luedde (1922) had a patient, aged ten, who developed a cataract from an injury and during the subsequent six years the vision in the other eye increased from $^{16}/_{60}$ to $^{16}/_{15}$. Herrnheiser (1900) reported a child, aged eleven, whose vision, after a traumatic cataract formed, developed from ability to count fingers at 1·5 metres distance to ability to count fingers at four metres in two weeks (eccentric fixation), to $^6/_{24}$ vision in three months, and to $^6/_9$ in one year. Bielschowsky (1926) watched a fourteen year old boy for two years following an injury which produced a large central scotoma of the fixing eye. During the first ten days the vision improved from $^1/_{30}$ to $^1/_{12}$, during the first ten weeks to $^1/_8$, and to $^6/_{12}$ by the end of the second year. A second patient (1896) under this oculist was aged eighteen when he lost his fixing eye. In ten weeks vision improved from $^1/_{15}$ to $^1/_6$ and in a year to $^1/_3$. Twenty-one years later he was found to have 0·9.

Moncreiff (1929), in summing up reports of spontaneous recoveries, stated that some who recovered had previously not even central fixation. Most patients did not recover completely, three certainly did, and most took months or years to recover, though one of Johnson's adults (1893-1894) recovered normal vision in fifteen days. It is interesting to recall Hurst's patient (1920) with hysterical blindness in one eye, which gradually disappeared when a syphilitic optic atrophy appeared in the other eye.

Recently I have been surprised at the improvement in vision following operation for strabismus. A girl, now aged fourteen, was first examined when aged four. On four separate occasions during her eighth and ninth years her vision was less than $^6/_{60}$. Three years after the eye was put approximately straight the vision was $^6/_{60}$, and now without any treatment it is $^6/_{18}$.

It is conceivable that the primary optic centres contain a "formative zone" where cells exist specially adapted to respond to visual impulses. A perception of a lower order, or rather a formless pattern, is produced here, but as impulses pass to the cortex, attention sensitizes this zone,

and the impulses are correlated into a pattern which arouses a definite perceptual pattern. On subsequent occasions similar impulses will arouse a more highly developed pattern as a primary response. "In instinctive reactions this occurs upon the first occasion, owing to the innate configuration of the formative zone" (Parsons). It is an instructive though unproven theory that implies a throwing out of dendrites to connect with those of adjacent neurones during the state of attention.

It appears that the stimulus of light is necessary for the development of the macula, and probably the prevention of clear image formation may interfere with the completion of this development and that of the central system of impulse coordination. If impulses are withheld, not only will the resistance of synapses fail to be broken down, but also the cellular adaptation which determines the response will be incomplete. This cellular zone is not simply the product of inheritance. It requires the elaboration that comes only from experience (Parsons). The complex cerebral processes underlying coordination may develop and become perfected for impulses from one eye during a period when impulses from the other are suppressed. If they are withheld too long, it may become too late for them to become correlated. The conditioning of the necessary reflex paths is a capacity of early life, just as the storing of the memory and concrete thought are characteristic of later years.

Previous observations show that though the period during which amblyopia can develop appears to be limited, fortunately the possibility of recovery is less restricted by age. A reversal of this state would mean loss of sight from the confusion due to diplopia of adult palsies and from non-use in cases of mature cataract in later life.

The educability of the retina and central connexions gives further support to the theory of *amblyopia ex anopsia*. If by constant stimulation one part of the retinal periphery can become a fixation centre, surely by constant occlusion and repeated education the structurally prepared macular can be educated. In false maculæ there is no structural change, but corresponding brain cells have either become more sensitive or have remained sensitive, while surrounding ones have become depressed.

The recovery of vision may be very gradual. It is of interest to recall the gradual development of vision when a congenital cataract is removed in an adult. Luedde (1922) quotes Dufour's and von Hippel's observations. The impression of movement appeared more elementary than one of form, and, in gaining a visual appreciation of movement, the sense of touch helped. Lister (1928) observed that a child, aged eight, who was learning to see after removal of a cataract, had at first to feel an object to identify it, and then she learned to recognize it by seeing it. Fisher (1914) reported a similar child, aged seven. This gradual development of vision throws light on the observation that by the perseverance of observer and patient at one visit, a considerable apparent improvement in vision may occur. Concentration may enable the patient to read $^{6}/_{24}$ when only $^{6}/_{60}$ could be seen at first.

To encourage parents during endeavours to abolish amblyopia, one can quote Luedde's patient, who was a doctor's daughter, aged nine. At the commencement of treatment the left vision was $^{16}/_{200}$. Five weeks after the commencement of occlusion, it was $^{16}/_{50}$. No improvement occurred during the next nine weeks, but at the end of six months the vision was $^{16}/_{20}$.

von Hofe (1930), in an investigation of squint amblyopia, found that children could often see simple forms when they failed to recognize corresponding letters or numbers. In one case circles or triangles corresponding to $^{5}/_{20}$ were seen, when the visual acuity with letters and figures was only $^{3}/_{50}$. At times a patient could grasp only part of the sign on view. In such cases the patient found it easier to recognize the form if he was permitted to trace its outline with his finger in the air. At times the test objects were described as feeble or floating into one another. These patients tired more easily during testing, and were more easily distracted than those with normal vision. On the whole, the function of the visual organ appeared on a more primitive level. Later the child reads with a carefulness akin to that of the proof-reader, which is far removed from the facile reading of a student. A similar gradual development was noticed by Hurst when teaching an eighteen year old deaf mute to hear.

Snellen (1924) considers that paresis of both external recti is the cause of concomitant strabismus. He explains the absence of diplopia by stating that the image of the deviating eye is formed on a peripheral and relatively insensitive part of the retina, and so it does not sufficiently arouse the attention of the patient. In paralytic squint, diplopia is due to the fact that the patient's attention is equally aroused by both eyes because in looking straight forward the deviation is inconsiderable, and therefore the image of the object looked at will be on one macula and close to the other. He considers that the deviation in squint is not the same in different directions, and that the presence of bilateral paresis explains the equality of the primary and the secondary deviations. The amblyopia is not from non-use in his opinion, but the non-use of one eye is due to the amblyopia. Most surgeons have observed an hypertrophy of the abductors and a partial atrophy of the abductors. This they attribute respectively to the excessive convergence and the corresponding inhibition of the antagonistic muscles. Landolt (1923) agrees that paresis of an abductor is a common cause. He regards absent binocular vision and the amblyopia as the main causes, and postulates a vicious circle. The child "squints because his binocular vision is not developed and binocular vision is not developed because he squints."

It is advisable here to consider for a moment the means by which an eye is enabled to fix an object.

The axis of fixation and its accurate maintenance depend mainly on the development of a sensory gradient. It is not the high acuity at the macula *per se*, but the marked reduction in acuity producing a high gradient around it that makes accurate fixation possible. In the

light adapted eye a uniform sensory gradient exists around the fovea which extends to the periphery. In dark adaptation a new axis is selected 1° or 2° from the light adapted axis of fixation, because a paracentral portion of the retina has become the apex of the gradient (Simon, 1904). The macula is more susceptible to education than other retinal areas because of its specialized structure and blood supply, because of its situation optically and because of latent cerebral potentialities. The infant takes several weeks to learn accurate fixation, and we know that the macula continues to develop during the first few months of life. Mann states that:

> The specialization of the rest of the retina is almost complete by the ninth month, and development practically ceases, while in the central region it continues apace until at least 16 weeks after birth, the slight initial retardation being thus correlated with a longer growth period and a more highly specialized final condition.

This includes an uncovering of the highly specialized cones by disappearance of overlying layers.

Fixation is an art learned during the slow acquisition of a sensory gradient. It implies cooperation with a perfectly controlled set of six extrinsic muscles and an optical system able to form a clear image at the apex of the gradient.

If this gradient is slow in developing, or if its progress is arrested by disease, neglect or active suppression, defective fixation will result. Fixation cannot be acquired without attention, and every change of fixation is determined and preceded by a change of attention (Parsons).

Is there a constant feature in convergent strabismus? A more or less disturbed fusion faculty is the only one. Worth, in a series of 157 non-squinting brothers and sisters of squinting children, found 106 with normal fusion. None of these subsequently squinted. Of 14 who had very deficient fusion sense, eight developed later a constant squint. Fusion may not be much disturbed, but in many squinters it is relatively insufficient to cope with the demands made on it by the dissociation of convergence from accommodation in hypermetropia. If the relation between accommodation and convergence were inelastic, every ametrope would squint. "The ordinary hypermetrope," however, "learns instinctively to accommodate more, the ordinary myope less than he converges, in accordance with the nature and degree of his ametropia" (Landolt). Desire for fusion permits this dissociation, and single vision and a clearly focused image are both retained. Defective binocular vision allows the close relationship of accommodation and convergence to predominate. This functional association in the absence of binocular vision can be demonstrated if we screen one eye of an emmetrope. On placing a concave sphere before the other eye, the former will converge. One must remember, too, that the concave sphere leads to accommodation in both eyes, and that if the one eye maintains fixation, the convergence of the screened eye will correspond to the double act of accommodation and so will be double the degree necessary if one eye is not

screened. In other words, it takes on the convergence of the fixing eye as well. The ability to dissociate can be shown by screening one eye of a hypermetrope and by quickly uncovering it while the other fixes an object. If he has good binocular vision, immediately on doing this the object will not appear double or indistinct. This proves that he has learned to associate with the necessary act of convergence sufficient accommodation for distinct vision.

It is interesting to note a type of divergent strabismus seen at times in which the eyes can be held straight except when the patient is exerting three or four diopters of accommodation when one eye diverges.

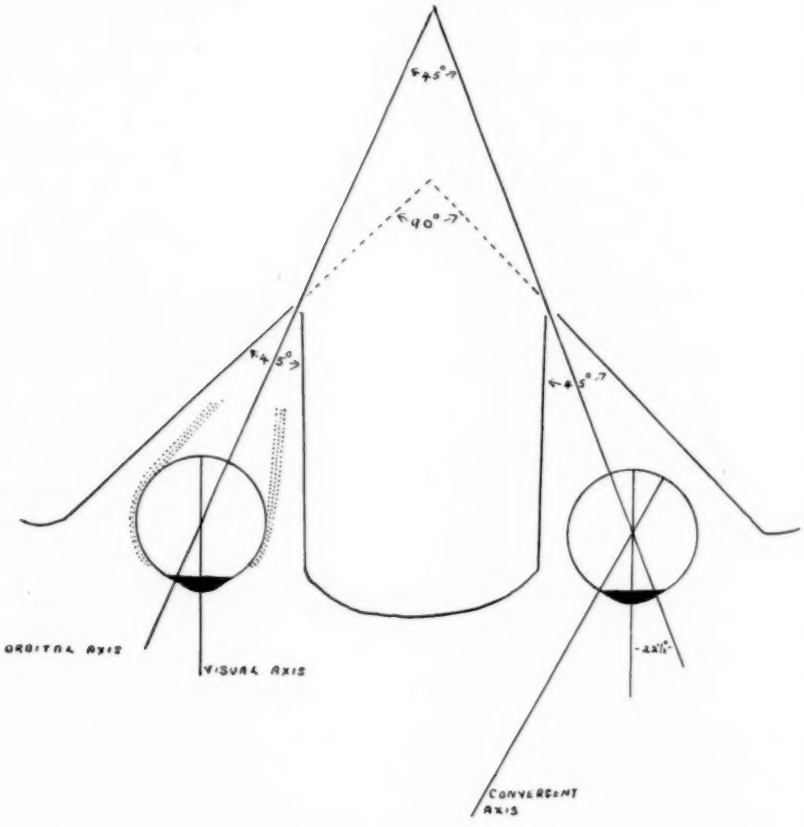
Most patients with convergent strabismus are hypermetropic, but some are only slightly so, and others are even myopic, whilst most children with hypermetropia do not squint. The part that hypermetropia may play is shown by squinting eyes which become parallel when the hypermetropia is nullified by atropine or corrected by convex spheres. When one remembers the relative infrequency of myopia during the first five years of life, the preponderance of hypermetropia appears less. Worth certainly found only 1·5% of 1,636 cases of squint had bilateral myopia, but then at the age of five 80% of children are hypermetropic and only 5% are myopic (Herrnheiser). Tenner in New York found 91% to be hypermetropic at five years and 48% at sixteen. At ten years of age 60% are hypermetropic and 10% are myopic. During the first two years of life, myopia is probably still less common. Similarly only 25 of 1,348 patients with unilateral strabismus had more than eight diopters and not more than ten diopters of hypermetropia, that is, less than 2%. But then a very small percentage of infants have such a high degree of hypermetropia.

Other factors which may upset an immature fusion faculty, are muscular anomalies and, more important still, illness and nerve upsets. Sufficient emphasis has been placed on illness, but it is necessary to stress the latter. An increase in convergence during the first visit of a nervous child to a doctor has often been observed. The eyes of a five year old girl converged for a whole day after a severe scolding at school, even though tests showed a moderate ability to fuse. The effect of any such shock depends on the stability of fusion in the child. Teething was observed recently to reverse a strabismus in a child, which had been changed from one eye to the other by the use of atropine. The possibility of squint and amblyopia developing after a shock being due to hysteria must not be forgotten (Hurst, 1920). Heredity undoubtedly plays a part in the production of strabismus. Probably it does so by influencing either the refraction or the fusion faculty, a recent phylogenetic gain.

WHY DOES SQUINT TEND TO RECOVER SPONTANEOUSLY?

Thomson (1924), in a series of 50,000 school children, found strabismus twice as frequently at the commencement of school life

(3·07%) as at the end (1·61%). In a smaller group he found it to be only one-fifth as common at the age of sixteen. He also found it to be twice as common amongst poor class city children as amongst those of the better class. Barrie found 37% of patients with strabismus at the age of seven had parallel eyes at the age of thirteen.



Peters considers that anisometropia is a feature of cases which spontaneously improve, and that the children learn to fuse about puberty. He found that, even though a central scotoma persisted, years later when the eyes were straight they all had good fusion. Other factors are the declining incidence of hypermetropia and the development of fusion. During the first decade hypermetropia falls from over 95% to 60%.

Van der Hoeve (1925) believes that fusion tends to produce orthophoria in the static relations of eyeballs and orbits, which, if left uninfluenced by fusion, would cause everyone to squint. As a rule some form of imbalance remains latent. Duke Elder states that exophoria is the most common muscle anomaly. But Thomson (1925), when examining non-squinting children, found 68% to be esophoric, and only 22% to be exophoric. Amongst 486 non-squinting children he found esophoria to be 4·69 times as common as exophoria in the hypermetropic group, 1·83 times in the myopic group, 7·25 times in the anisometropic group, and 9·5 in the emmetropic group. In none of the groups was orthophoria more common than 5%. It is especially interesting to note that in myopes without squint not only did he find esophoria more frequently than exophoria, but also that in them convergent strabismus was more common than divergent strabismus (1 to 1·4). Not only is there is a tendency for strabismus to disappear, but there appears to be a tendency for eyes to become divergent as age increases.

Unfortunately, this tendency to diverge has caused the belief amongst parents and even doctors that children grow out of strabismus. And, as Priestley Smith has said, the "wait and see" policy in squint leads as a rule to waiting and not seeing. Even if such children escape without amblyopia, they usually do not develop stereoscopic vision.

There is evidently a tendency for the visual axis to diverge with age and so to conform more to the axes of the orbits which diverge on the average 45°. The distance between the orbital axes at their anterior extremities in the adult male is sixty millimetres, whilst in children it is only forty-eight millimetres (Emmert). The muscles of the eyes are apparently most relaxed when there is a slight divergence. Possibly the amblyopic convergent eye begins to swing outward when the control of the synergism of accommodation and convergence ceases. This innate tendency to diverge is seen when one eye is blind and in deep sleep, narcosis and after death.

It is tempting to suggest that excessive near work and other demands of civilization have turned the eyes inwards before the bony parts have accommodated themselves, and that convergent strabismus is the defect of a transition period. Possibly, too, those people who can control fusion, breaking it at will by moving independently one eye at a time, have gone a stage further on in development. The occasional association of such movements, however, with a voluntary nystagmus suggests that they are due to some weakness of conjugated movement and a reversion to the type seen in lower animals [Balduzzi (1922), Guist (1925), Kolen (1925-26)].

STEREOSCOPIC VISION AND THE FUSION FACULTY.

This brings us to the second great problem in strabismus, namely, stereoscopic vision and the fusion faculty. It is wise to recall the age-long and laborious struggle as seen in the history of the race that has led to the attainment of stereoscopic vision. One cannot appreciate the

difficulties by a study of the brief recapitulation seen in the young child, the even tenor of whose way is scarcely disturbed by the development of this faculty.

Low forms of life are concerned with two planes of space, but elevation of the head, ascent into the air or descent into water entailed acquaintance with three planes. The appreciation of the third dimension became a survival factor, a matter of life and death. The perception of depth means binocular vision, and this is seen especially developed in carnivores, whether dwellers on land, in trees, the air or in the sea. As the forelimbs were freed from locomotion, and displaced the jaws as weapons and implements, the snout receded and was replaced as a guide to food by the eyes which advanced from the lateral to the frontal position. Two separate fields and wide panoramic vision were superseded by overlapping fields and binocular vision, so that the perception of distance and depth might be gained. Wideness of view now began to depend largely on wide open lids, a larger cornea and greater ability to rotate the eye and head.

Once survival began to depend on the functioning of both eyes as a single organ, it became necessary that the sensory and motor nerve paths must cross the mid-line as the reins of a pair of horses must cross for efficiency. Other essentials for binocular vision were the ability to converge and its association with accommodation. With these developed a more sensitive macula and so the foundations for stereoscopic vision were laid. The macular cones developed a fibre each, and probably bilateral representation in the cortex. Both in the cortex and in the retina the macular centre is protected by a special blood supply. Once the central cones developed a fibre each, the threshold for the discrimination of the distance between two points was raised. In the periphery each fibre supplies a group of percipient elements, and so it constitutes an organ that is specially differentiated for the discrimination of differences in position. Its sensitivity to feeble stimuli is greatly increased. The dark-adapted eye is many thousand times more sensitive than the light-adapted eye.

Smell was the dominant sense until it failed to supply information necessary for survival. A transitional stage appears in certain carnivores which rely on smell for the pursuit of prey and vision for its capture. The eyes were called on to give information to the animal concerning the position in space and the movements of objects in view. To keep one's eye on the branch, as Keith puts it, it was essential to combine the images of each eye. Vision of objects on one side required that temporal fibres should run a direct course so as to work with the opposite crossed nasal fibres. Convergence and the perfect coordination of twelve extrinsic muscles made concentration on objects in the mid-line possible. This demanded that the temporal halves of the maculæ should work together, that their fibres should cross.

An increasing number of non-decussating fibres at the chiasma became necessary and the close segregation of fibres from the homolateral

side of each retina before reaching the cortex. Each hemisphere could then receive impressions of objects in the contralateral half-fields of vision, and the brain would receive two views of an object from slightly different points of view. The ability to fuse two such dissimilar views is gradually developed. The singleness of binocular vision is "the product of a synthesis that works with already elaborated sensations contemporaneously proceeding" (Hughlings Jackson, Parsons).

Stereoscopic vision implies the perfect functioning of many related structures. Primary reflex and the response of the individual to an innate desire for fusion play a part in its development. This late acquisition of the race may be denied the individual by the presence of varied disabilities. These include ocular defects due to defective development, refractive errors demanding excessive accommodation, mechanical defects of the extraocular muscles and a delayed development of the fusion faculty itself, or the absence of the desire for fusion.

How readily the eyes descend the hill, climbed with such effort, is seen during unconsciousness, and is demonstrated by the divergence of an eye when blindness breaks the bond of fusion. It is the fusion faculty which prevents those who have heterophoria from developing strabismus, and in sickness the change from heterophoria to squint is due to a weakening of this faculty. Clinically we make use of the prolonged occlusion test, by denying the aid given by this faculty, and so the true muscular balance is revealed. We literally take the fusion mechanism to pieces, rendering asunder what years of labour joined together. As an example, let me refer you to the following patient.

A doctor's wife had been unable to read for more than twenty minutes for four or five years. She was found to have 1·5° of left hyperphoria and 10° of exophoria. After occlusion of one eye for four days she had 4° of hyperphoria and 22° of exophoria. When the hyperphoria was corrected in full, and the exophoria in part, the patient was enabled to read for four or five hours and has done so ever since.

This faculty of fusion is normally fully developed by the sixth year. It may, however, only develop incompletely, and then the will of the individual is called upon to play a larger part than normally. Fortunately the cooperation of other individuals is possible here.

TREATMENT.

The object of this paper is to increase our incentive to treat strabismus, and the main incentive is the justifiable belief in the acquired origin of amblyopia and its disappearance by education. It is my intention merely to summarize the methods of treatment.

One must examine the patients at the earliest possible date. In a review of the excuses for delay of treatment given by parents in the Strabismus Clinic at the Alfred Hospital, the inevitable "wait and see" tendency is prevalent. Two other reasons are frequent. Firstly, the parents knew that squint sometimes disappeared with age. Secondly, a doctor said: "Nothing can be done till the child is seven." The refrac-

tion must be estimated under atropine and errors fully corrected. If the convergence excess persists, bifocal lenses may be used to lessen accommodation further. Emerson (1905) first advocated this practice, and was followed by Duane, Reber (1915), Maddox (1930) and Ryer (1923). Reber (1915) orders an additional three diopter convex spherical lens for near vision at the first refraction, and then reduces this by one diopter each year. Sattler (1927) orders prisms as high as 22° in extreme cases before each eye and gradually reduces them till no manifest squint remains without the prisms and binocular vision is established [Hooren (1920), Maddox (1930)]. This treatment hastens the removal of troublesome false projection.

The preeminent need, however, is to develop the vision in the eye that appears to be amblyopic. One attempts to reverse the squint and then to obtain an alternating tendency. One may atropinize the better eye and remove its correcting lens. If this fails, one must occlude this eye. As a rule one fixes a thin cardboard shield over the eye with plaster, or uses collodion to keep a gauze covering on. Ether removes the former fixative and acetone the latter. A report is received from the parent once or twice a week. Even if visual acuity does not markedly improve, fixation is established and suppression arrested. Let me quote you the following case from many similar ones observed.

A girl, aged six, had squinted with her left eye for three years. When first seen the right eye could read $^6/_{18}$ and the left eye less than $^6/_{60}$. The right eye was tied up, and three weeks later the right eye remained convergent. Three months later the left eye was tied up until the right began to maintain fixation again. The eye was reversed several times. After nine months the vision had improved to $^6/_{12}$, and at the end of fifteen months it was $^6/_6$. Exercises were then commenced with the synoptophore. At the third visit fusion was possible at 45°.

Once the squint has been reversed, one can start fusion training. At times, if the development is slow, it is wise to give the patient some exercise with Maddox's cheiroscope or Elliot's synoptophore. With the former, young children can be trained to use the squinting eye and the hand of the same side together. Accommodation is relaxed by the use of spheres. The two images can be approximated by the use of a mirror and the attention of the child is held by encouraging it to draw and play with minute toys. In the development of the individual "the hand under the guidance of vision becomes the instrument of the mind" (Mott, 1904). "Tactile impressions are those into which most visual impressions have to be translated before their meanings can be known." Parsons (1927) supports "the analogy of macular or active vision with active touch, in which the macula corresponds to a finger-tip." "Vision may be said to have inherited function in space perception from the tactile sense of which it is a higher differentiation."

The synoptophore of Elliot is of more general use. It is the greatest advance in squint training apparatus of recent years. With the synoptophore one first of all attempts to establish simultaneous binocular perception with related slides (hands in clock). Simultaneous macular perception is next obtained by a pair of slides

similar to Worth's "bird within cage." Then the development of fusion must be attempted. Movement of the slide before the weaker eye tends to arouse perception. It is of interest to recall the very primitive nature of the appreciation of movement and its later subjection to the ability to perceive detail as the macula evolves. In amblyopia there is primarily a removal of the epicritic characteristics of central vision and the remaining sensation is more primitive in type. In hemianopia, whether epileptic (Harris) or due to occipital injuries (Riddoch), perception of movement was restored before the ability to perceive shape or colour.

At home, if the cooperation of intelligent parents is available, the greatest improvement may be effected by the use of a stereoscope and pictures of the Hegg type. As an example, I will refer to the following patient.

He was a boy, aged five, who fortunately had a father who was interested and anxious that full stereoscopic vision should be developed. The left eye had converged for two years. The left vision was less than $^6/_{60}$, and after occlusion of the right it had increased to $^6/_{24}$, partly, at the end of five months to $^6/_{12}$, partly, at the end of seven months. The stereoscope was supplied then, and six months later the left vision was $^6/_6$ and he was found to have good stereoscopic vision (amplitude 12°).

If this paper can increase interest in the removal of amblyopia and the production of fusion and, more particularly, if it encourages the formation of strabismus clinics, your time has not been wasted. The clinic at the Alfred Hospital is known as the Sight Saving Class, simply as an endeavour to change the emphasis from the obvious defect to more important issues.[1]

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[1] Since writing this paper the author summarizes the above treatment as follows: Occlude till squint alternates, then correct squint angle with prisms and train with synoptophore and stereoscope.

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AN ANALYSIS OF NINE HUNDRED AND NINETY-FIVE CASES OF ACUTE APPENDICITIS TREATED AT THE MELBOURNE HOSPITAL.[1]

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This paper is based upon an investigation of the histories of 995 patients suffering from acute appendicitis admitted to the Melbourne Hospital during the three year period, July, 1925, to June, 1928. Care has been taken to exclude all cases in which there was any doubt whether the appendix was acutely inflamed. Conclusions based upon statistical studies are frequently erroneous, so much so that the statistician is often described as the superlative of a well-known comparative, but the liability to err is reduced when the review embraces a large series of cases. It, therefore, seems reasonable to presume that the mortality rate and the percentage incidence of complications in this series, embracing nearly one thousand patients operated upon not only by members of the honorary surgical staff of the hospital, but also in many instances by the resident staff, indicate with sufficient accuracy the results of our methods of treatment of this disease. This statement must, unhappily, be qualified in two directions. In the first place, children under fourteen years of age are not admitted to the hospital and, as it is well known that the mortality from acute appendicitis is high in the first years of life, our death rate is lower than it would be if children had also been treated. In the second place, Mr. Julian Smith, Junior, Dr. R. Wright-Smith and Dr. E. W. Gault, who have earned my sincere gratitude by making abstracts of the case histories of this series, have informed me that this task was made unnecessarily difficult by the fact that some house surgeons had been too careless and lazy to make proper progress notes. In some histories in which the temperature chart indicated that the post-operative convalescence had been far from smooth, there were no progress notes of any sort. It is to be hoped that some singularly evil fate awaits these house surgeons, and their default makes it necessary to explain that the percentage incidence of complications is slightly lower than it should be.

Mortality.

There were 52 deaths, a total mortality rate of 5·2%. In two cases no operation was performed and the diagnosis was made at autopsy,

[1] This article has been published in *The Melbourne Hospital Clinical Reports* and is reproduced by permission of the editor.

and in one instance death occurred during the induction of anæsthesia. If these cases be excepted, the operative mortality rate was 4·9%. These figures are similar to those reported in other countries. St. Leger Brockman[1] reports a mortality of 4·7% in 1,068 cases, Grey Turner[2] a death rate of 5·13% in 681 cases, J. McN. Love[3] 5·2% in 1,285 cases and C. J. Miller[4] 9·9% in 2,415 cases. Miller's figures include many cases occurring in the negro population in America, in whom the death rate is always higher than in whites. It must, therefore, be recognized that at present one in every twenty patients suffering from acute appendicitis dies of the disease; that, despite improvements in surgical technique and in methods of anæsthesia, there has been no reduction in the mortality rate during the last twenty years; that, in fact, this disease remains "a menace to the public, a disgrace to the profession and a challenge to those of us who practise the science and art of surgery" (Miller).

The death rate in appendicitis is due mainly to delay, as is shown in Table I.

TABLE I.

Mortality in relation to Delay.

Day of Operation.	Number of Cases.	Number of Deaths.	Percentage Mortality.
First day	400	2	0·5
Second day	277	15	5·4
Third day	126	14	11·0
Fourth to seventh days ..	141	11	7·8
Over one week..	50	8	15·0

The mortality rate among patients operated upon in the first twenty-four hours is almost negligible, but it rapidly increases to 11% among those operated upon on the third day. It then falls slightly, only to rise again in this series, to a maximum of 15% in cases in which the infective process has lasted for more than a week—a fact which will receive further comment.

The blame for the delay in performing the operation does not rest entirely upon the shoulders of the public, though the fact that approximately one-third of the patients did not come to the hospital until on or after the third day of the disease indicates the necessity for further efforts to teach the public that it is dangerous to neglect a belly-ache, and that the initial pain of appendicitis is usually central rather than on the right side. That some responsibility must be borne by the hospital staff is shown by the fact that an erroneous initial diagnosis was made in thirty-three instances. Twenty-seven of these patients were treated by a "wait and see" policy which is described, in hospital parlance, as "stalking" the patient, a term apparently derived from the sport of deer stalking, which is not devoid of a certain grim humour, for the "bag" in the 27 cases was 11 deaths. The majority of these patients were at first thought to be suffering from pyelitis, owing to the fact

that pus cells and colon organisms were found on microscopical examination of the urine. It appeared that this discovery was accorded undue significance as compared with the signs found on examination of the abdomen. It seems reasonable to suggest that house surgeons should be reminded that pyelitis confers no immunity from appendicitis, and that it is less culpable to remove a normal appendix than to overlook one which has perforated. Next to pyelitis in order of frequency was an erroneous diagnosis of entero-colitis due to food poisoning. It is not generally recognized that, though constipation is the rule in acute appendicitis, diarrhœa is not an insignificant exception, as it occurs in approximately 5% of all cases. Other mistaken diagnoses which led to delay in operation were typhoid fever, pleurisy, cholecystitis and pneumococcal peritonitis. Two cases were diagnosed at autopsy; one of the patients thought to be suffering from infective endocarditis was found to have a pylephlebitis due to acute appendicitis, and the other, a demented patient who could not give a history of his illness, died of general peritonitis caused by rupture of a gangrenous appendix. In six cases an erroneous pre-operative diagnosis was made which did not lead to delay in performing the operation. Of these, four were thought to be due to perforations of duodenal ulcers, one to a ruptured ectopic gestation and one to acute intestinal obstruction. In four of these cases an unnecessary upper abdominal incision was made and two of these patients died. The hospital staff, therefore, made an incorrect diagnosis in 33 cases (3·3% of the total number), and 13 of these patients died (a mortality of 40%). As it is difficult to gather from the histories the precise facts which led to these errors in diagnosis, it would be most instructive if, in the future, cases in which similar mistakes occur were reported.

Another factor which weighs heavily in the balance against the patient is that of age, as is shown by Table II.

TABLE II.

Mortality in relation to Age.

Decade.	Number of Cases.	Deaths.	
2	295	14	
3	355	7	(mortality rate under 40 years, 3%)
4	148	2	
5	102	11	
6	50	5	
7	40	10	(mortality rate over 40 years, 14%)
8	3	1	
9	1	1	

These figures confirm the well-known fact that the death rate from acute appendicitis increases with age. This is due partly to the fact that the signs and symptoms are often atypical. In six of the 28 cases in which death occurred among patients over forty years of age, opera-

tion was delayed owing to a belief that the disease was not appendicitis, and six others were not admitted to hospital until on or after the third day of the disease, probably owing to difficulty experienced by the medical attendant in making a diagnosis. In the remaining 16 deaths the factor of decreased resistance, as shown by the development of secondary abscesses, or that of associated pulmonary or renal disease, determined the result. It is of interest to note that the percentage mortality among patients aged from fourteen to twenty was 4·7%, whereas in patients aged from twenty to forty it was 1·7%—a fact which confirms the statement already made that if the Melbourne Hospital treated patients in the first decade of life, the total death rate would be appreciably higher.

It is obvious from these figures that the problems confronting us in the treatment of this disease are those which are engaging the anxious attention of surgeons all over the world. Our figures, if no worse, are certainly no better than those already reported by many writers in other countries and, further, are no better than those reported two decades ago. The mortality in this series among 126 patients operated upon on the third day of the disease is 11%, whereas the mortality in 708 similar cases, reported by Edmund Owen[5] in 1914, was 10·7%. Despite all attempts to educate the public that early operation is essential, it is certain that in the future surgeons will still be confronted by cases in which the odds are heavily against success owing to the duration of the disease. It also seems certain the outlook will not be materially improved by mere refinements in surgical technique. Realizing these facts, many surgeons are testing the efficacy of what is known as expectant treatment of patients seen for the first time on the third to the fifth day of the disease, when the natural resistance of the patient is at its lowest and when there has not been time for the development of an acquired resistance to the infection. McNeill Love describes the routine, when patients are given the benefit of delay, as follows:

> The patient is placed in Fowler's position, water only is allowed by the mouth, and fomentations may be applied to relieve pain. After twenty-four hours, if the signs and symptoms of infection are subsiding, this treatment is continued until the temperature and pulse are normal; the patient is allowed fluid diet (milk, Benger's food *et cetera*) when he expresses a wish for it, which time usually coincides with the approach of the temperature to normal. Operation is performed one week later, unless physical signs still suggest an abscess, which usually absorbs within another week. . . . If, after a period of delay, the temperature and pulse still remain elevated, or an abscess increases in size, then an operation must be performed.

Love reports a mortality of 1·9% after operation successfully delayed and of 6·5% after operation unsuccessfully delayed; that is, a total mortality of 3·5% among all patients treated expectantly as compared with a total mortality of 6·24% in similar cases in which immediate operation was performed without any preliminary expectant treatment. Love adopts expectant treatment whenever

cutaneous hyperæsthesia has disappeared, irrespective of the time which has elapsed since the onset of the infection. His figures are, therefore, not confined to patients submitted to operation on or after the third day. The cases in this series in which operation was delayed, are not sufficiently numerous to enable any deductions to be drawn. Though many surgeons believe that the expectant method is bad and that to delay operation in appendicitis is to "gamble with death," it seems reasonable to suggest a trial of this method at the hospital. This suggestion is made with two definite reservations. In the first place, it is necessary that the test should be made by one or more surgeons who are able to supervise personally each case in which operation is delayed, and, in the second place, until the value of expectant treatment is proved, it would be wrong to teach students any variation of the doctrine that the "time to operate in appendicitis is as soon as the diagnosis is made."

Before leaving the subject of delayed operation in appendicitis, it is necessary to refer to the high death rate among patients operated upon after the end of the first week, namely, 15% (see Table I). In all these cases an abscess was present and an analysis of the histories reveals a definite change in operative procedure. In the year 1925-1926 it was apparently the uniform practice to search for and, if possible, to remove the appendix in cases of this nature. In the two succeeding years many abscesses were drained without an attempt being made to find the appendix. In 1925-1926 there were four deaths after removal of an appendix from the wall of an abscess cavity and two deaths in similar cases in which an unsuccessful search was made for the appendix. In the years 1926-1928 twenty abscesses were treated by simple drainage without a death, whereas two deaths occurred in these years when appendicectomy was performed in the presence of an abscess.

It is also evident that some patients were operated upon when the abscess was small and that at the operation infective material escaped into the general peritoneal cavity. When an abscess is present, as Wilkie[6] has stated, there is not only a time to operate, but also a time not to operate. When, some time after the onset of the attack, there is a palpable mass with relatively little constitutional disturbance, the indication is that resolution is proceeding and operation may result in the patient falling a victim to ill-timed surgery. If a large abscess has developed, it should be drained by the most direct route without any attempt to remove the appendix. There is no doubt that the alteration of the operative methods in the last two years under review has been followed by a decrease in the mortality rate in this class of case. It is obvious that the method to be employed in any individual case must be left to the discretion of the operating surgeon, but it is impossible to avoid the conclusion that some of the earlier deaths in this group of cases were avoidable.

When the patient has recovered from the abscess, an operation for removal of the appendix should be performed. The necessity for this step

is shown by the fact that in three of the twenty cases already mentioned in which simple drainage was performed, a second acute attack occurred within a few months. This second attack was typical in two instances, but the third patient was not readmitted to hospital until after a second abscess had developed and had ruptured in the lateral sacral region. Two cholesterin stones discharged through the sinus and, when the appendix was removed, a third cholesterin stone was found in it. All three patients recovered after removal of the appendix.

It was, unhappily, impossible, owing to the meagre descriptions of the condition of the appendix given in many of the operative notes, to draw up a table showing the mortality in relation to its condition, nor could an estimate be made of the number of cases of the obstructive type of appendicitis in which sudden and complete obstruction of its lumen leads to tension gangrene and rupture.

In Table III the deaths are grouped in relation to the types of fatal complications of the disease.

TABLE III.[1]

Deaths in relation to Fatal Complications.

Complication.	Number of Cases.	Number of Deaths.	Time.
Peritonitis		14	Under two days.
Peritonitis with ileus	52	16	Three to ten days.
Subphrenic abscess		6	Two to eleven weeks.
Pelvic abscess		3	Two to twelve weeks.
Pylephlebitis	3	3	Six to eight weeks.
Uræmia		3	Seven to ten days.
Bronchopneumonia		3	One to two weeks.
Pulmonary embolism	1	1	Eighth day.

[1] Two unoperated cases and one death occurring during the induction of anæsthesia are not included in this table.

The significance of these figures can best be determined by a review of all the post-operative complications recorded in this series.

COMPLICATIONS.

Peritonitis.—It was impossible to determine the number of cases in which general peritonitis was present, because of the lack, in many histories, of an accurate description of the extent of the infection of the peritoneum. Fourteen patients died soon after operation from toxæmia due to general peritonitis, the result of undue delay, but it is reasonable to suppose that they were beyond aid at the time of operation. In a desperate attempt to save life, the operation of lymphaticostomy was performed in one case without success.

Post-operative Ileus.—Severe abdominal distension during the first few days after operation was reported in 52 cases, an incidence of 5·2%. This complication, though sometimes unavoidable, is frequently caused by faulty technical methods. It is relatively uncommon when the surgeon

has been able to coax the infected appendix from its bed without at the same time delivering and ill-treating adjacent coils of small intestine. The less that is seen of the small intestine in an operation for acute appendicitis, the better is the outlook for the patient. In 41 cases the distension was treated in the usual manner by the administration of purgatives by the mouth, pituitary extract given subcutaneously and high enemata. The composition of the enema employed was often not recorded in the history, but sisters of experience have expressed equal preference for an enema of five ounces of milk mixed with five ounces of treacle or one composed of an emulsion of two ounces of turpentine, three ounces of olive oil and three ounces of soap and water, which is introduced after the foot of the bed has been raised and is followed in half an hour by the injection of three pints of soap and water. Whatever may have been the detailed treatment adopted in each individual case, the net result was that of 41 patients treated medically, 34 recovered and seven died.

An attempt to relieve the obstruction by draining the small intestine was made in 11 cases and the results are shown in Table IV.

TABLE IV.

Operative Methods for the Relief of Ileus.

Type of Operation.	Number of Cases.	Deaths.
Jejunostomy	6	5
Ileostomy	4	3
Ileostomy followed by jejunostomy	1	1
TOTAL	11	9

Though these results compare unfavourably with those obtained by the use of medical measures, it must be emphasized that only the most severe cases were treated by bowel drainage, and that, in consequence, it is a matter for congratulation that two patients were saved. In many of the cases the operation was performed as a final gesture of despair. Ileostomy has been performed more frequently at the hospital since the period under review in this paper, and it seems probable that, as a result of the display of better judgement in the choice of the time of operation, future reports will show a decline in the mortality rate.

Intestinal Obstruction.—Intestinal obstruction, due to kinking of the bowel by adhesions, occurred in five cases, an incidence of 0·5%. It is remarkable that this complication is not more common during convalescence, in view of the fact that some matting of coils of small intestines takes place in every case of local or general peritonitis. The obstruction, which manifested itself in all cases during the second week after operation, was promptly diagnosed and treated by liberation of the affected coils by division of the adhesions. In two cases, which are not of course included in Table IV, an ileostomy was performed in

addition to this procedure. Despite the fact that the mortality from intestinal obstruction due to adhesions is high (Barnard has reported a death rate of 68·4%), there were no deaths in this series from this complication. It must be recognized that the high mortality rate is due mainly to delay in operating, for which there is no excuse when obstruction occurs in a patient actually under observation in hospital.

Residual Abscess.—The results of the treatment of subphrenic and pelvic abscess are shown in Table V.

TABLE V.

Residual Abscess.

Type of Abscess.	Number of Cases.	Deaths.
Subphrenic abscess:		
(*a*) Between liver and diaphragm	9	6
(*b*) Subhepatic	2	0
Pelvic abscess	6	3
TOTAL	17	9

A distinction has been made in this table between cases of subphrenic abscess in which suppuration was limited to the subhepatic spaces and those in which the right anterior or posterior peritoneal subphrenic spaces were involved, because in the former adequate drainage was provided by the simple procedure of a stab incision in the loin, whereas in the latter rib resection was required.

The mortality from subphrenic abscess, even when the two patients with subhepatic abscess who recovered are included, reached the high level of 54·5%. There were six deaths among nine patients in whom suppuration occurred in the right anterior and right posterior intraperitoneal space. Excluding one fatal case in which the abscess was first discovered at the *post mortem* examination, there were five deaths after drainage by a transthoracic route, a mortality of 62·5%. In three cases, in two of which recovery occurred, drainage of an associated empyema was necessary, and in two cases a fatal issue was inevitable owing to the presence of extensive suppuration in the liver. The death rate from subphrenic abscess requiring drainage through the chest wall is always high, owing partly to delay before the diagnosis is made and partly to the difficulty of establishing adequate drainage, but these figures compare unfavourably with those reported by other surgeons. Barnard[7] records a mortality of 27% among twenty-six cases in which drainage was established through a transcostal incision in the scapular line, a mortality of 39·5% among forty-three cases in which drainage by the anterior route was adopted and a mortality of 75% in four cases in which the lateral transthoracic route was selected. His figures clearly indicate that the outlook after posterior operations is more favourable. Fifield and Love[8] report a death rate of 43·7% in thirty-two cases

in which a subphrenic abscess was drained through the pleural cavity, and emphasize the importance of establishing posterior drainage, which, they state, is usually practicable even when the anterior space is involved. Though it is unjustifiable to draw sweeping conclusions from the results obtained in such a small number of cases, it seems that the importance of posterior drainage was not sufficiently appreciated in this series. There were two deaths in three cases of right anterior space abscess, in all of which drainage was established by the anterior transcostal route, and three deaths in five cases of suppuration in the right posterior space in which lateral drainage seems to have been uniformly adopted. The development of a subphrenic abscess can frequently be prevented by drainage of the paracolic gutter, either through the wound or through a separate small incision in the loin. This precaution was not taken in the cases in this series in which this complication occurred, for in two the wound was closed without drainage and in the remainder a tube was passed down into the pelvis. Though the incidence of subphrenic abscess has been decreased by the adoption of Fowler's position, the routine use of a suitably placed drainage tube in suspicious cases will still further diminish its frequency. This is shown by the fact that during the year 1919-1922 no case of subphrenic abscess occurred at the London Hospital in cases of acute appendicitis in which drainage had been established by a stab wound in the loin (Fifield and Love).

It is interesting to note that difficulty in making a diagnosis led to a fruitless exploration of the upper surface of the liver by the transthoracic route in two cases in this series. Though it is undesirable to operate for an alleged subphrenic abscess when pus cannot be found with an exploring needle, no evil effects followed this procedure.

There was a surprising mortality of 50% in six cases of residual pelvic abscess. In the three fatal cases the abscess was drained through a suprapubic incision. A similar procedure was followed by recovery in two cases, but in the third successful case vaginal drainage was established. There is no record in this series of drainage of a pelvic abscess in male patients through the rectal wall, but the results of evacuation through an abdominal incision are so bad that it seems desirable that this method of obtaining dependent drainage should be employed in suitable cases. A factor of importance in the development of a residual pelvic abscess when drainage has been used is the practice of progressively shortening the drainage tube, a step which invites the development of pus pockets at the bottom of the track and which, therefore should be abandoned in favour of the method of replacing the tube by another of smaller diameter but equal length. This tube can, if necessary, be replaced in its turn by one still narrower, for decreasing the diameter prevents the development of unpleasant complications due to pressure on organs in the wall of the drainage track, while maintaining the original length prevents pocketing in its dependent parts.

Though a residual abscess, either subphrenic or pelvic, developed in only 1·7% of the total number of cases, the fact that the mortality of this complication was 47% is a sufficient indication of its gravity.

Wound Infection.—Wound infection was noted in the progress reports in one hundred and seventeen cases, an incidence of 11·7%. In twelve it was necessary to reopen the wound or to make incisions in its vicinity. There were no deaths from this complication.

Fæcal Fistula.—A fæcal discharge from the wound was reported in fifteen cases; thirteen of the wounds healed spontaneously and two were successfully closed by a plastic operation.

Hæmorrhage.—In one case it was necessary to reopen the abdomen because of reactionary hæmorrhage and in two instances secondary hæmorrhage occurred from vessels in infected wounds. There were no deaths from hæmorrhage.

Pulmonary Complications.—Signs of lung consolidation were recorded in forty-eight cases, 4·8% of the total number, but it is impossible to determine from the histories the relative incidence of pulmonary infarction and bronchopneumonia. Death was caused by bronchopneumonia in three instances, and in these the diagnosis was verified at autopsy. One patient successfully withstood a typical attack of lobar pneumonia during convalescence from acute appendicitis.

Other Complications.—Femoral thrombosis occurred in nine cases, pylephlebitis in three, catarrhal jaundice in two, severe pyelitis in six, and four patients became insane after the operation. In three cases it was stated in the *post mortem* report that death was due to uræmia.

Drainage in Acute Appendicitis.

The problem of drainage in acute appendicitis has aroused much discussion in recent years. St. Leger Brockman, advocating a more restricted use of the drainage tube, states that though in many cases the advantages of drainage are obvious, there are a large number in which its sole value is its hypnotic influence upon the surgeon. He reports a decreased incidence of fæcal fistula and of intestinal obstruction due to adhesions, together with a complete immunity from residual abscess, in the absence of drainage. In his opinion, it is in many cases unnecessary to use drainage, even when the appendix is gangrenous or has perforated, providing that the disease has been present for less than three days, the patient is over twelve years of age, the degree of toxæmia is not excessive, cyanosis is not present, and there is not a large area of raw tissue left after removal of the appendix. He is also guided by the condition of the peritoneal exudate, and agrees with Wilkie that drainage is required when an immediate investigation of this fluid reveals a lack of large mononuclear cells, their failing power of absorbing stains and an absence of phagocytosis.

In this series, drainage was adopted in three hundred and eighty-two cases, 38·4% of the total, and it appears that the dictum, "when in doubt, drain," was generally obeyed. Not long after the publication of

St. Leger Brockman's article, this policy was occasionally abandoned, with immediate and catastrophic results, in that subphrenic abscess occurred in two undrained cases, in one of which the patient died; peritonitis with ileus occurred in another undrained case, the patient died; and pylephlebitis occurred in a fourth case, and in this instance the wound was closed without drainage after the removal of a gangrenous appendix. Though these results may not have been improved by the use of a drainage tube, there seems little doubt that the surgeons concerned would have felt happier had they enjoyed the "hypnotic influence" of its presence.

Viewing the problem from another angle, the hospital figures justify the belief that the disadvantages of using a drainage tube have been exaggerated. There were fifteen cases of fæcal fistula, two of which occurred when drainage was not used, so that the incidence after drainage was only 1·3%. Residual abscess developed in two cases in which drainage was not used, a fact which diminishes the cogency of the argument that drainage predisposes the patient to this complication. It was unfortunately impossible to determine the late incidence of intestinal obstruction from adhesions, but this complication developed during convalescence in only five cases.

It seems probable, therefore, that an improvement in the death rate from acute appendicitis will be achieved rather by more widespread education of the public that delay is dangerous, by advising an early exploratory operation in doubtful cases and by further investigation of the value of delayed operations than by attempts to limit the use of the drainage tube.

SUMMARY.

1. An analysis is made of the histories of 995 cases of acute appendicitis, occurring in patients treated at the Melbourne Hospital during the three year period, July, 1925, to June, 1928.

2. The total mortality was 5·2% and the operative mortality was 4·9%.

3. An erroneous initial diagnosis was made in 33 cases and 13 patients died, a mortality of 40%.

4. The influence of age is shown by the fact that the mortality among patients under forty years of age was 3% and over forty years of age 14%.

5. A systematic investigation of the value of delayed operation in selected cases is recommended, in view of the fact that the death rate from acute appendicitis has not decreased during the last twenty years.

6. The incidence and treatment of post-operative complications are reviewed, with special reference to ileus and residual abscess.

7. This review indicates that the disadvantages of drainage in acute appendicitis have been exaggerated.

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[3] R. J. McNeill Love: "Some Observations on the Treatment of Acute Appendicitis," *The British Journal of Surgery*, Volume X, 1922-23, page 520.

[4] C. Jeff Miller: "A Consideration of the Mortality of Acute Appendicitis, with Special Reference to 239 Fatalities," THE JOURNAL OF THE COLLEGE OF SURGEONS OF AUSTRALASIA, Volume III, 1930, page 40.

[5] Edmund Owen: "Appendicitis," 1914.

[6] D. P. D. Wilkie: "Observations on the Mortality of Acute Appendicitic Disease," *The British Medical Journal*, February 14, 1931, page 253.

[7] H. L. Barnard: "Contributions to Abdominal Surgery," 1910.

[8] Lionel H. Fifield and R. J. McNeill Love: "Subphrenic Abscess," *The British Journal of Surgery*, Volume XIII, 1925-26, page 683.

Case Reports.

"ENDOMETRIOMATOUS" BOWEL STRICTURE, WITH AN UNUSUAL COMPLICATION.

By CHARLES GALE,
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A NUMBER of cases of "endometrial" involvement of the bowel have been reported, although the majority have not given rise to clinical signs or symptoms. However, Mouat[1] reports two cases resulting in stricture. The following case is interesting inasmuch as, in addition to producing stricture, it was complicated

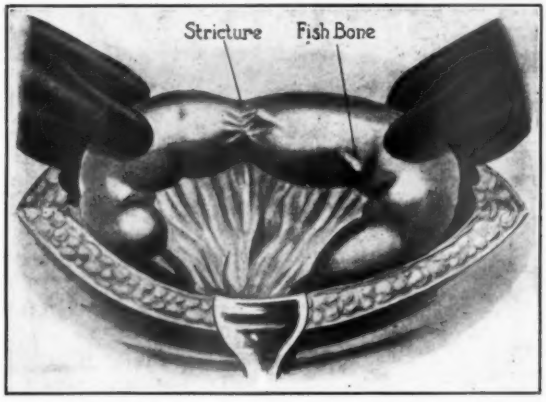

FIGURE I. Appearance of the bowel at operation showing the "endometrious" stricture of the ileum with the impacted fishbone.

by impaction of and perforation by a fishbone of the bowel wall immediately proximal to the stricture.

E.B., a female, aged thirty-nine years, was perfectly well, with no previous illnesses of note, until three months before admission to hospital, when she had an attack of slight diarrhœa, without vomiting, of twenty-four hours' duration. Thereafter she was quite well until two hours after a usual evening meal the day before admission. She had a gradual onset of central abdominal colicky pain; the pains were at first mild, but soon became severe. During the night each attack of colic was accompanied by severe vomiting and cold sweats, the former being forcible and consisting of gastric and later bile stained intestinal contents. This was never fæculent. During the morning of the day of admission the pains and vomiting became much less, the former settling down to a constant dull ache in the right iliac fossa. The bowels were not open for forty-eight hours prior to admission, in spite of attempts by the patient. *Oleum ricini* was taken on

morning of admission, but was immediately vomited. The patient had had no preceding indigestion, pain nor irregularity of bowel action, apart from the isolated instance three months before this illness. Her menses were regular in spacing (four weeks), the duration was three to four days and flow slight. She had no dysmenorrhœa, no intermenstrual discharge and no pelvic discomfort. Her obstetric history consisted of three normal confinements, with neither anæsthetic nor instrumentation, twenty-three, twenty-two and twenty years ago respectively; her husband was deceased nineteen years. There had been no miscarriage. Examination on admission disclosed a woman who was not looking very ill, with a temperature of 37·5° C. (99·6° F.), a pulse rate of 104 and a respiratory rate of 18; she had a dry white furred tongue and "abdominal" breath. The upper part of the abdomen moved well with respiration, though the right lower quadrant exhibited slight rigidity and considerable tenderness. There was no hyperæsthesia and no mass palpable; the psoas and obturator tests were without result. Vaginal examination disclosed slight tenderness in the right fornix, but no mass. Immediate operation revealed much free slightly purulent fluid and a hyperæmic appendix, which was removed.

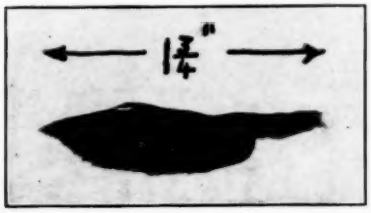

FIGURE II. The fishbone which caused the perforation of the ileum. (Natural size.)

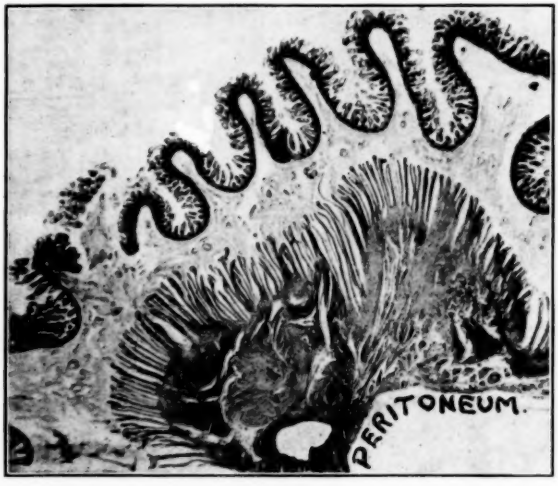

FIGURE III. Photomicrograph of a section of the wall of the bowel showing a cyst near the peritoneal surface. × 6.

Section of the appendix showed that the engorgement was confined to the peritoneal and subperitoneal coats. Further investigation revealed a mass in the ileum, about 60 centimetres (two feet) proximal to the ileo-caecal valve. Inspection revealed a fibrotic constriction distal to which the bowel was collapsed, while just above it was slightly dilated and contained a fishbone (see Figure II), which had penetrated the ballooned bowel in one spot (see Figure I). Excision of the stricture,

together with 12·5 centimetres (five inches) of bowel proximal to the stricture and of the associated mesentery containing a large soft gland was performed. End-to-end anastomosis was made, and the abdomen closed rapidly owing to the patient's condition and with drainage down to the appendical stump. The ovaries were not examined.

Post-operative convalescence was uneventful and afebrile after the second day. There was steady fairly copious purulent discharge from the tube down to the appendical site, which gradually diminished and ceased by the third week.

Macroscopically the bowel exhibited fibrous puckering with peritoneal adhesions and thickening of bowel at one point. Microscopically (see Figures III

FIGURE IV. Higher power photomicrograph showing the structure of a portion of the "endometrial" tissue. × 30.

and IV) the bowel wall was invaded by endometrium-like tissue. The pathological report stated: "A typical example of so-called endometriosis, metastatic in the wall of the gut, and probably originating from the ovary."

The case is interesting in that:

1. The diagnosis at operation was carcinoma of the bowel.
2. The "endometrioma" produced intestinal obstruction of sufficient degree to cause impaction of the fishbone, and resultant perforation.

Acknowledgement.

My thanks are due to Mr. E. S. J. King for permission to record this case.

Reference.

(1) T. B. Mouat: "Two Cases of Stricture of the Bowel by Misplaced Endometrial Tissue," *The British Journal of Surgery*, July, 1926, page 76.

STRANGULATION OF SMALL INTESTINE.

By R. W. COOPER,

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THOUGH as far back as 1861 Quain(1) described a case of strangulation of small intestine through an opening in the broad ligament found *post mortem*, very few similar cases have since been recorded.

Robert Jones[2] reports two cases of strangulation of intestine through definite openings, and refers to one other.[3]

Strangulation in pouches in the region would appear to be much commoner. The condition is apparently so rare that the following case is worthy of being placed on record.

Mrs. McA., aged seventy years, was admitted to hospital at 12.30 a.m. on March 15, 1931. She had always been well, and was the mother of a grown up family. There had been no trouble with any of the confinements, and she had had no abdominal operations. Some slight constipation had been her only complaint, and there was no recent loss of weight. Three days previous to admission she began to complain of colicky pains about the umbilical region, with variable radiation over the abdomen. With the application of heat the pains gradually settled by the end of the second day. The next day the pains recurred, being then more severe and colicky, and most marked towards the lower part of the abdomen on the right side. She vomited once, and had had no bowel action since one induced by medicine two days previously. A doctor was called and the patient's admission to hospital arranged.

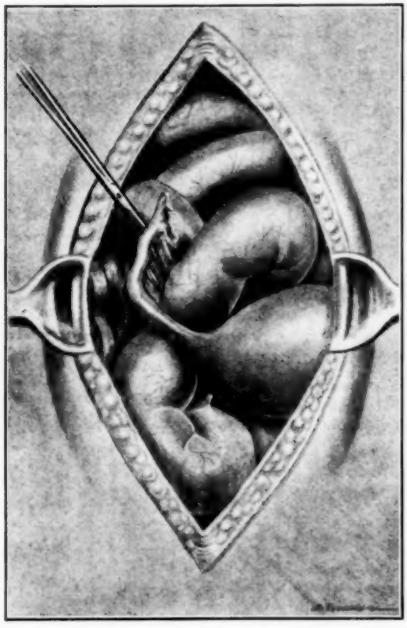

Figure showing the appearances found at operation. A coil of ileum had passed through the right broad ligament posteroanteriorly and had become obstructed.

Examination revealed an old lady, anxious and distressed, and evidently in pain. The temperature was 36·1° C. (97° F.) and the pulse rate 80. The tongue was furred, but the breath not "abdominal." Some moderate distension of the abdomen was present, with the outline of coils of intestine showing through the thin wall below and to the left of the umbilicus. Generalized tenderness and rigidity were present, most marked in the right iliac fossa about 2·5 centimetres (one inch) below McBurney's point. There was no evidence of free fluid or gas in the peritoneal cavity. Rectal and vaginal examinations showed tenderness in the right fornix with apparent thickening.

An immediate laparotomy through a right lower paramedian incision disclosed distended small intestine and a collapsed caecum and colon. The site of obstruction was found to be in the right pelvic cavity, where a coil of terminal ileum approximately 22·5 centimetres (nine inches) in length was found to be strangulated through a hole in the broad ligament. The gut had entered from the posterior aspect through a hole, the thin friable edges of which suggested that it had only recently been formed. The right tube had been compressed by the tension imposed on it, and was almost gangrenous. The loop was freed by removing the tube, and its circulation quickly recovered. There was no other sign of recent or old inflammation in the pelvis, and the adjacent organs appeared to be healthy. The patient had an uninterrupted recovery and was discharged in ten days.

Multiparity would appear to be the only common ætiological factor in the cases so far described. In Quain's case, a right-sided one, there were definite

adhesions between the broad ligament and the mesentery, apparently the result of old puerperal inflammation, and the tension was considered to have caused a fissure in the broad ligament. In both of Janes's cases the opening was on the left side and the bowel had entered from in front. Unless, perhaps, due to severe peristaltic action pressing the bowel through, no feasible explanation of the occurrence presents itself.

Acknowledgement.

I am indebted to Mr. E. S. J. King for permission to report this case.

References.

(1) Quain: "Case of Internal Strangulation of a Large Portion of the Ileum," *Transactions of Pathological Society of London*, 1861, Volume XII, page 103.

(2) R. Janes: "Two Cases of Intestinal Obstruction due to Strangulation of a Loop of Small Intestine in an Opening of the Left Broad Ligament," *The British Journal of Surgery*, October, 1929, Volume XVII, page 333.

(3) H. Barr: *Medical Record*, 1920-1921, June, quoted by Janes.

Reviews.

A TEXT BOOK OF SURGERY.

A TEXT BOOK of surgery, by Associate Professor Homans, is a little out of the common, since it does not follow the lines of the ordinary text book.[1] This work, compiled from the lectures and other writings of the members of the Surgical Department of the Harvard Medical School, reflects in lecture form the surgical teaching of a famous medical school rather than that of an individual.

An attractive feature of the book, and one which adds to its interest, is the short, informal and often anecdotal historical sketch at the beginning of the section devoted to each subject.

A chapter is devoted to surgery of the sympathetic system, and prominence is given to the work of N. D. Royle and the late John Irvine Hunter. The author enumerates and describes the various pathological conditions which modern surgical experience has shown are definitely benefited by the various forms of sympathectomy. In relation to the increasing use of operations on the sympathetic, he gives this timely advice: "It is easy to understand the temptation to make use of such procedures for the treatment of obstinate ulcers in parts poorly supplied with blood, of painful states of pallor, discoloration and impending gangrene in the extremities and of crippling arthritis, any lesions, indeed, which are likely to be benefited by a more vigorous blood supply; but it will be more profitable, until a fuller knowledge of the sympathetic outflow is available, to restrict operative paralysis of the regional sympathetic supply to such states as can be cured in no other way."

Diseases of the bones and joints are treated clearly and concisely, and completeness is sacrificed to the relative importance of subjects. In order to bring out the various diagnostic points and thus make clear the all-important X ray diagnosis of bone diseases, simple sketches are effectively used for illustrations instead of the actual skiagrams.

The chapters on cranium, meninges and brain bear the impress of Professor Cushing's teachings. The pathology and treatment of brain tumours are brought up to date. The treatment of abscess of the brain, a subject of practical importance to the general surgeon, is carried out by aspiration only, or by tissue fixation of its walls and marsupialization; but never by making large openings and using drainage tubes.

[1] "Textbook of Surgery," by Associate Professor Homans; 1931. London: Baillière, Tindall and Cox. Crown 4to., pp. 1212, with 513 illustrations. Price: 40s. net.

We were particularly attracted by the description given of the clinical manifestations and variations in the onset and course of appendicitis. Any general practitioner or surgeon who reads this clear and practical exposition should not fail to recognize the onset of these atypical forms of appendicitis which are often so fatal if not operated on in the early stages.

There are chapters on the surgical treatment of pulmonary tuberculosis and of bronchiectasis. Sections of the book are devoted to gynæcology and to genito-urinary diseases. The book is well but simply illustrated, and has a special bibliographical index. It is a work on surgery which will appeal, not only to the surgeon and general practitioner, but also to the student, who should read it in conjunction with his ordinary surgical text books.

WORK AT THE MAYO CLINIC.

VOLUME XXII of the "Collected Papers of the Mayo Clinic and Mayo Foundation," for 1930, is to hand.[1] This book is well known to surgeons and general practitioners the world over. It reflects the work and teaching of the Mayo Clinic, aptly described as the Mecca of all who love the art and practice of surgery. The present volume is in every way a suitable sequela to those of previous years. The practice of reproducing in full some of the papers published from the clinic is to be commended. It shows clearly the value put on them at their place of origin. Those of lesser importance are given in abridged form or in abstract, and others again are mentioned by name only. The papers written in 1930 numbered 482. Of these 85 are reprinted in full, 30 are abridged, 55 are abstracted and 312 are referred to by title only.

The book, as usual, is divided into several sections; the first deals with the alimentary tract, the second deals with genito-urinary organs, and then follow sections on ductless glands, blood and circulatory organs, skin and syphilis, head, trunk and extremities, chest, brain, spinal cord and nerves, technic [*sic*], and there is a miscellaneous section.

The papers on surgery of the stomach are invaluable. The physiological and chemical studies following successful gastrectomy for carcinoma shows the need for attention to this aspect of surgery. The review of the gastric carcinoma-gastric ulcer problem by W. C. MacCarty will be read with interest by all surgeons. There are other papers on unsatisfactory results in the surgical treatment of peptic ulcer and on the results of gastro-enterostomy. Surgery of the duodenum is introduced in several papers. There is an interesting paper by F. W. Rankin and J. R. Learmonth on section of the sympathetic nerves of the distal part of the colon and the rectum in the treatment of Hirschsprung's disease and certain types of constipation. These authors lay emphasis on the difference in the post-operative course of patients suffering from Hirschsprung's disease and those suffering from rectal constipation. A paper on carcinoma of the cervical stump following subtotal hysterectomy by C. H. and C. Mayo should do something towards eliminating the incomplete operation. In the section of surgery of the chest appears an interesting paper by S. W. Harrington on the results of the surgical treatment of 24 intrathoracic new growths. In an important paper on intravenous anæsthesia J. S. Lundy shows that intravenous anæsthesia by means of barbiturates alone is not justified, because of the occasional untoward results incident to their use.

Merely an indication of the type of article likely to appeal to surgeons has been given. This will serve as a reminder to those who know the volume and an incentive to initiate the habit of buying the book to those who do not know it.

[1] "Collected Papers of the Mayo Clinic and the Mayo Foundation," edited by M. H. Mellish-Wilson, R. M. Hewitt, B.A., M.A., M.D., and M.A. Felker, B.S.; Volume XXII; 1930. Published 1931. Philadelphia: W. B. Saunders; Melbourne and Christchurch: James Little. Royal 8vo., pp. 1125, with illustrations. Price: 63s. net.

ESSAYS ON RESEARCH.

"ECONOMIC ability is being bred out of our race, the acquisitive instinct is being eliminated, society, as at present constituted, is selectively breeding to destroy itself." This is not the utterance of a political pessimist, but an extract from an article, "What Are 'The Fit'?" the last of a collection of twelve papers by the late Professor Brailsford Robertson, of Adelaide, edited by his wife under "The Spirit of Research."[1] Towards research Robertson's attitude is one of reverence: the search for truth was his religion. Those who are not minded to take part, but busy themselves with other activities, are merely "house-keeping." No investigation is too humble or seemingly unimportant, no lack of opportunity is to be pleaded, "do the best you can with what you have where you are." Monetary success and recognition are of minor importance and often prove to be a curse. With them come the "practical man" and the financier, the former to utilize forthwith and lead the investigator away from his shrine, the latter to gather where he had not strawed. In "The Cash Value of Research" the author contrasts the meagre pittance provided for research with the vast wealth which it produces. The universities have little time or money to spare from teaching, in commercial institutions it "occasionally pursues a stunted career, subject to all the caprices of momentary commercial advantage and the cramped outlook of the 'practical man'," while the institutions existing for research alone can readily be enumerated and their incomes are comparatively small. Two remedies are suggested: university endowments must explicitly provide for the furtherance of research, and the profits accruing from inventions must be taxed and the proceeds devoted to scientific research.

The shabby treatment accorded the investigator (as it is preferable to call him) is again referred to in "The Strategics of Scientific Investigation," with a special measure of contempt for the professional politician "whose momentary recognition of the danger of ignoring the investigator" has led to various schemes being put forward which "betray little comprehension of the real needs and potentialities of the investigator." The author points out some of the disadvantages of the crowding together of investigators in the vicinity of large centres of population. For one thing, it leads "through constant personal interchange of views, to a certain uniformity of thought which not infrequently becomes indistinguishable from prejudice," so that different groups of observers come to have different views on the relative importance of different hypotheses. For another, men of undoubted capabilities may live far from the present centres.

Of the remaining articles, the two entitled "Consciousness and the Sense of Time" and "The Mechanistic Origin of Finalism" are particularly intriguing. Readers of a speculative and philosophical turn of mind will find therein material for mental merycism.

The introduction, by Dr. Pennycuick, gives a short account of Brailsford Robertson's life and work. It is enough to say that few, on coming to the last page, will not straightway turn again to the introduction to re-read the brief account of an all too brief life.

TRAUMA IN SURGERY.

IN coining the word traumatotherapy for the title of the second edition of his book on traumatic surgery, Dr. John J. Moorhead apparently hopes to succeed where others have failed.[2] Many similar words—traumatocace, traumatocomium,

[1] "The Spirit of Research," by T. Brailsford Robertson, Ph.D., D.Sc., Edited by J. W. Robertson; 1931. Adelaide: F. W. Preece and Sons; Sydney: Angus and Robertson. Crown 8vo., pp. 221. Price: 8s. 6d. net.

[2] "Traumatotherapy, the Treatment of the Injured," by J. J. Moorhead, B.Sc., M.D., F.A.C.S. (D.S.M.); 1931. Philadelphia: W. B. Saunders Company; Melbourne and Christchurch: James Little. Royal 8vo., pp. 574, with 625 illustrations. Price: 42s. net.

traumatology, traumatonesis, traumatopnœa, traumatopyra and traumatosaprosis—have all passed into disuse and it would be surprising if "traumatotherapy" were even to survive its birth.

The book itself is written for the most part in numbered paragraphs and lettered subsections, like so many lecture notes, in a peculiar abbreviated fashion with many "pluses" and "the sames." The letterpress is interspersed with vernacular, but contains much of interest and practical value. About one-third of the book is given to a description of fractures, other sections deal with dislocations, "closed cavities trauma," traumatic neuroses, amputations, "soft part plastics," post-traumatic deformities, standardized appliances and treatment for first-aid, restoration of function and medico-legal and allied aspects, to mention most of the subjects discussed. The value of some of the methods recommended is doubtful. For instance, the treatment of fractures of the coccyx by rectal splinting with a rubber tube wrapped in oiled gauze, open operation as the treatment of choice in simple fractures of the radius or ulna, and incision into hæmatomata of the scalp, which may resemble depressed fractures, may well be questioned. In regard to hæmatoma of the scalp, the author states that it is wiser "to incise than to surmise." The relationship of trauma to malignant disease, which one might expect would be fully discussed in a book such as this, is treated somewhat airily. Head injuries would appear not to exist apart from fractures of the skull. Some of the anatomical errors are to be wondered at. We learn (page 71) that "the interphalangeal cartilages are also frequently involved" (in injury). Other errors occur, for example, in diagrams of the tendon sheaths of the hand, of subglenoid dislocation, of the loss of sensation in the palm of the hand following injury to the median nerve; on page 193 there is a diagram which is quite unintelligible.

A review of this book would be incomplete without reference to the author's love of aphorisms and succinct and amazing phrases, a few of which are as follow: "Once an osteomyelitis, always an osteomyelitis." "There are four R's in fracture therapy: *Recognition* (or differential diagnosis); *Reduction* (or setting); *Retention* (or splitting); *Restoration* (or rehabilitating). Of these, the brightest lexicon (*sic*) is Reduction." "Our rule is to require motion every two hours to and from a right angle twice for the first two days—'the rule of two'." "Osteomyelitis is like cancer, in that no one can say how long it will *stay cured*, whatever the treatment, radical or otherwise." "Pyocyaneus is a good omen and to me is the equivalent of the 'laudable pus' of our forefathers." "This patient is certainly not the wren type; no, that is a bird of another plumage or vintage—not infrequently a parrot." It is a queer book.

MORBID ANATOMY.

PROFESSOR ROBERT DONALDSON, of the University of London, and Director of the Pathological Department of Guy's Hospital Medical School, has produced the second edition of his book, "Practical Morbid Histology."[1] It is described in the subtitle as "A Handbook for the Use of Students and Practitioners." In the preface the author states that the book is intended not only for students beginning the study of morbid histology, but also for practitioners who find it necessary to revise their pathology in preparation for one of the higher examinations. For this purpose the book is admirably suited. It is arranged along conventional lines. After a chapter on inflammation, organization and repair, there is one on specific inflammations. Then follow chapters on diseases of the heart, blood vessels, lungs, liver, pancreas and intestines, kidneys, spleen hæmopoietic bone marrow, thyreoid gland and suprarenal glands. There are chapters on dystrophies of bone, diseases of the central nervous system and then come chapters on tumours. Chapters deal with epithelial tumours, connective tissue tumours, melanomata and so on. In each section there is a short introduction, then follows a description

[1] "Practical Morbid Histology: A Handbook for the Use of Students and Practitioners," by R. Donaldson, M.A., M.D., Ch.B. (Ed.), F.R.C.S.E., D.P.H., with foreword by Sir Humphry Rolleston; Second Edition; 1931. London: William Heinemann (Medical Books) Limited. Crown 4to., pp. 497, with 214 illustrations. Price: 42s. net.

of the morbid anatomy (the macroscopical appearances) and this is succeeded by a section on the histological appearances. The facts are clearly and concisely stated —there is no padding.

In the foreword, Sir Humphry Rolleston states that the book is not for the armchair, but for the *post mortem* room and the adjacent laboratory, where the gross end results of disease and characteristic microscopical sections can be duly correlated. This suggests that the book will be useful to practising surgeons, who obviously must have access to books of reference on pathology. It will be useful to surgeons only if they have a certain amount of practical knowledge to guide them. A man, for example, who was not *au fait* with the macroscopical appearances of the liver in different diseases would have to turn to the several paragraphs labelled "Morbid Anatomy" under the sections dealing with cloudy swelling, fatty infiltration, fatty degeneration, chronic venous engorgement, amyloid degeneration, focal necrosis, hepatitis and so forth. This would necessitate a considerable amount of reading and of turning of pages. The book is written from the academic aspect of the different diseases and not from the more practical standpoint of the appearances likely to be found when an examination is made—in other words, there is nothing on differential diagnosis. We have mentioned the liver; the plight of a surgeon desirous of classifying a tumour of the breast with the aid of this book would be worse, for breast tumours are described under the headings of the different types of tissue.

The book may be recommended for the purposes described by the author in his preface.

ESSAYS.

IF Professor Walter Murdoch, of the University of Western Australia, were known by no other means, he would be spoken of in all parts of the Commonwealth and even beyond its shores as the author of "Speaking Personally," a book of essays which was received with pleasure by all sorts of people. In that book Professor Murdoch established his popularity. He has followed it by a second volume, "Saturday Mornings."[1] This volume is as full of charm as the last, the variety of subjects is handled with the same ease, and the reader at the end of each essay feels not only pleased, but stimulated. The author does not "preach" so much as he did in his first volume, but he often has a message and delivers it almost by stealth. Most medical practitioners will be given food for thought in "A Confession"—an essay dealing with the inability of most people to be appreciative of new methods in art and literature after the age of forty; it might well be called "The Middle-aged Look." Much as we should like to take readers with us along some of the paths of literary and general interest chosen by Professor Murdoch, we must refrain owing to lack of space. This is a book which each reader may give to himself for a Christmas present; it will give him many hours of pleasure.

Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

AFTER-TREATMENT OF OPERATIONS ON GALL BLADDER AND DUCTS.

PROFESSOR E. MELCHIOR, of Breslau, contributes to the third volume of *Der Chirug* (June 15, 1931) an article dealing with the after-treatment of operations on

[1] "Saturday Mornings," by Walter Murdoch; 1931. Australia: Angus and Robertson. Crown 8vo., pp. 240. Price: 6s. net.

the bile tract. He deals with the special tendency to post-operative respiratory complications. He attributes this tendency to two main causes: first, to interference with respiration, which is attendant on any operation in the region of the diaphragm; and, secondly, to the fact that patients suffering from long-standing disease of the gall bladder or its ducts have generally become habituated to the use of narcotics. In such circumstances special prophylactic measures must be taken. Atony of the stomach is also a post-operative complication; it is due to the handling and retraction of the stomach when it is necessary to remove adhesions connecting it with the gall bladder.

Melchior strongly deprecates the use of gauze packs and drains. He regards their use as unnecessary, a cause of dense adhesions and of incisional hernia. He states that solely and only on account of persistent oozing of blood, which is not controllable by the ordinary means, is the use of gauze tampon justified today.

He then passes on to discuss post-operative "cholæmic" hæmorrhage. He points out that this hæmorrhagic tendency is not necessarily associated with jaundice, but is a sign of general liver inefficiency. He stresses, in this respect, that in obstructive jaundice the bile acid content of the blood falls somewhat and that the cause of the hæmorrhage is the absence, rather than the presence, of bile acids in the blood. This is shown experimentally: when the liver is extirpated in animals, it is found that the blood becomes non-coagulable. In practice this hæmorrhagic tendency has an important influence on the mortality rate; and, to counter it, Melchior advises calcium administration for several days, particularly in the form of intravenous injections of "Afenil." Blood transfusions are in his opinion more useful still. He refers to Braun's suggestion at the Surgical Congress of 1923, that such a transfusion might well be adopted as a prophylactic measure in all cases, and recommends it especially when the severity of the infection demands urgent operation, and when there is no time to carry out the treatment with calcium. Cholæmic post-operative hæmorrhage should be treated by transfusion, 200 to 300 cubic centimetres of citrated blood having a sufficient hæmostatic effect.

Quite apart from the symptomatic hæmophilia, general liver insufficiency may present an uncontrollable, often fatal picture; the patient will not rouse himself after the operation, or, if he does awaken, soon relapses into a state of somnolence giving a picture resembling general intoxication. This is caused by a flooding into the blood of the intermediate products of protein metabolism, and by interference with the hepatic function of sugar metabolism. After experimental extirpation of the liver, the animal soon succumbs to a coma due to hypoglycæmia. In man, after operation, there occur symptoms resulting from inability of the liver to fix glycogen. Melchior recommends the administration of grape sugar to combat this failure and thus to restore the liver cells. At least 100 grammes of grape sugar, combined with 10 to 20 units of insulin, should be administered every day; the sugar may be given either by mouth or by the rectum. At the same time, a failing heart must be stimulated. If respiratory troubles occur, lobeline is given. Operation, Professor Melchior points out, should never be undertaken in the presence of definite liver insufficiency; and, in particular, the use of "Avertin" in the presence of well marked liver damage is never justifiable.

Melchior firmly believes in using drainage, without exception, in all cases of cholecystectomy. The length of time during which an hepatic duct drainage tube should be left *in situ* depends more on the nature of each individual case than on a general rule. If there is no gross infection, if the bile discharge steadily lessens, and if the stools regain their normal colour, ten to fourteen days are enough. But, with severe infection or turbid bile, the period should be longer. The increasing secretion of well coloured bile is the favourable sign which he looks for in deciding how long to leave the drain in a common duct. If, in the course of hepatic duct drainage, the stools do not regain their colour after two or three weeks, he removes the tube, hoping that it may be the cause of the obstruction. More often, however, a definite obstruction must be sought.

Discussing the causes of persistent biliary fistula, he puts an overlooked stone first or, failing that, a small tumour of the papilla or of the pancreas. Such a tumour, he states, may easily be missed at the operation. Prolapse of the

papilla, which he has seen in two cases, has also been a cause. A complete obstruction, gradually developing after a period in which at least some of the bile has been reaching the duodenum, indicates a secondary stricture of the duct, caused by pressure ulcers due to the previously existent stones. Occasionally more favourable causes of a persistent fistula are spasm of the papilla, or inflammatory swelling of it, following long standing catarrhal inflammation of the duct.

Clinically the persistence of a fistula is of great importance, causing discomfort to the patient by maceration of the skin, disturbances of the digestion of fats from lack of bile, and disorder of the calcium balance, leading to a type of bone softening (Pawlow) and to a hæmorrhagic tendency.

In the treatment of fistula, conservative measures offer much hope in cases due to swelling or spasm of the papilla: magnesium sulphate or "Agobilin" by mouth, or "Decholin" given intravenously, or, better still, the passage of a duodenal tube and irrigation of the duodenum with 300 cubic centimetres of warm 15% magnesium sulphate solution. If these measures fail, Melchior advocates a more careful examination of the region of the obstruction by making an X ray examination after the sinus is filled with "Iodipin."

In cases of organic obstruction of the lower end of the common duct, anastomosis of the upper dilated part of the duct directly to the duodenum is the method of choice. In obstructions situated at a high level, an attempt may be made to dissect out the sinus and anastomose the dilated upper portion of the duct with the duodenum.

A. E. BROWN.

THE PROBLEM OF OPERATION FOR CARCINOMA OF THE RECTUM.

V. SCHMIEDEN, writing in *Zentralblatt für Chirurgie* (April 11, 1931), discusses the modern tendencies in operating for rectal carcinoma. While being of opinion that progress has been made in recent years on the debatable subject of the type of operation to be employed, he admits that there is considerable divergence of view among surgeons as to the best operative procedure. He insists on the principle that an abdominal exploration is the only means of determining the extent of the disease and the appropriate method to be adopted.

The rectum should be removed, together with its lymphatics and glands, as one mass in the same way as the breast and axillary glands are extirpated. The upward and backward spread of carcinoma is emphasized.

Schmieden draws attention to the researches of his colleague, Westhues, who, on the grounds of microscopical examination of recurrences of carcinoma after operation, considers that the portion of the rectum below the growth, as well as the mucous membrane above the tumour, is rarely affected. On the other hand, the perirectal connective tissues and lymphatics of the sacral hollow are early involved.

Thus theoretical considerations exclude the sacral operation as an ideal one for carcinoma of the rectum. The tumour is attacked from below, and though the perirectal tissues may be removed, the proximal suspicious area is cut through. Except in very early cases the operation is incomplete. Many patients later die from recurrences in the sigmoid and sacral area. According to Westhues, 72% of these fatal cases show recurrences in the mesosigmoid and mesorectum. Westhues also found that in 45% of all extirpated rectal growths the connective tissue mass above the tumour was already invaded. In Schmieden's experience, however, early carcinomata showed no lymphatic involvement.

The crux of the question lies in the recognition of the technical impossibility of removing, by the sacral route, the important lymph glands along the course of the superior hæmorrhoidal artery.

The sacral method has other disadvantages such as wound infection and the expression of tumour cells into the lymphatics by the inevitable manipulation of the tumour. The abdomino-sacral procedure, on the other hand, permits of securing all central blood and lymph vessels before the tumour is handled. The combined operation is thus the ideal one.

German surgeons, in 1924, were divided into three groups: (i) those who employed the abdomino-sacral method, (ii) those who considered each case from the individual standpoint and devised the operation accordingly, (iii) those who were opposed to the combined operation.

Schmieden believes that in practice these divisions are only apparent and that the extreme groups (i) and (iii) are tending to disappear.

In the interests of a lowered mortality, surgeons of groups (i) and (iii) are considering cases more and more from the individual's point of view. Although Schmieden would range himself with surgeons of group (i), he finds he frequently has to pursue a middle course, chiefly because of the contraindications on the patient's part.

The fact is that patients suffering from carcinoma of the rectum, by the time they seek surgical aid, are poorly nourished, have disturbed metabolism, are elderly and anæmic and have a defective cardio-vascular system often with fatty degeneration. These patients will not stand a major procedure, and so, whether surgeons wish it or not, they are forced to compromise. Furthermore, many of the patients have chronic obstruction and require an artificial anus before the anatomically correct operation can be carried out at a second sitting. If on abdominal exploration this second operation appears likely to be necessary, Schmieden divides the sigmoid mesocolon and pushes the closed lower end of bowel into the pelvis. The complete dissection of the pelvic colon, rendering the sacral operation more easy, is not always possible. Thin men and women with a wide pelvis are suitable for this procedure. In general, after the artificial anus has been made it seems better to open the abdomen again later to perform the pelvic dissection. If at the time of first laparotomy Schmieden finds that it is impossible to perform the combined operation, he makes the typical double-barrelled artificial anus and completes the operation later by the sacral route, using a method he describes as the posterior infolding procedure. It consists in infolding many times the closed end of the intraperitoneal stump of bowel in the sacral wound. The method of simple sacral resection finds only a small place in his clinic.

In his last 150 cases, in which operation was indicated, 14 patients had complete obstruction and 24 subacute obstruction on arrival. In 66 the provision of an artificial anus was all that could be done. In 30, the abdomino-sacral, one stage operation was performed, in 11 the two stage abdomino-sacral extirpation, in 19 sacral amputation of the rectum after a preliminary colostomy. Most of these were posteriorly infolded. In 18 a sacral resection and in some few cases artificial methods were adopted.

There is nothing gained in comparing the results of different methods. Statistics show very little, because of the comparison such different material. The best results are obtained by adapting the operation to the individual case. This collection of cases illustrates how far surgeons are from regarding today the abdomino-sacral operation as the normal method.

In the same period in Schmieden's clinic there were 41 combined operations compared with 37 sacral operations. He remarks that in America surgeons are reaching similar conclusions. He advises surgeons who would obtain the best results to consider the individual case, to avoid prejudice and pessimism and not to exaggerate the inconvenience of an artificial anus. The abdomino-sacral operation remains the method of choice and the one most likely to be free of recurrence. Schmieden probably voices the opinion of most experienced surgeons when he emphasizes the impossibility of placing all cases of rectal cancer in the same category. Although he does not give details of his abdomino-sacral operation, presumably it is the equivalent of the Miles operation. His modified sacral operation is indicated in cases for which the Mummery operation is so popular in England. In 18 cases he performed the sacral resection as opposed to the sacral amputation, so that presumably he finds a place for the local removal, similar to the Kraske, in selected cases. This is rather heterodox teaching in English schools, but since Schmieden is fully alive to the need of eradicating the lymphatic field, and as he himself states that the combined radical operation is the method of choice, due weight must be given to his opinion. He is interested more in prolonging life and giving his elderly patients reasonable comfort than in adhering to a rigid operative formula.

A. E. COATES.

Obituary.

ROBERT GORDON CRAIG.

By the death of Robert Gordon Craig, which occurred at Binnaway, New South Wales, on September 2, 1931, the Royal Australasian College of Surgeons has lost one of its most prominent foundation Fellows, one whose life and practice reflected the highest ideals of surgery, and one who was held in personal esteem and affection.

Gordon Craig was born in Ardrossan, Scotland, in 1870. He was always attached to the place and called the building in Macquarie Street, Sydney, which housed his private clinic by the same name. He was proud of his Scotch ancestry, and it is said of him that when he was with Scotch people his speech took on a broader accent. His father was a sailor and came to Australia as Superintendent of the Eastern and Australian Steamship Company. Young Craig did not accompany his father to Australia in 1877, but followed him in the next year. After a voyage full of incident and very near to tragedy, he arrived in Sydney and was sent to chool at Sydney Grammar School. When he was thirteen years of age he was taken back to Scotland and attended Watson's School, Edinburgh. Not much is known of his school days, beyond that he was look on as a promising lad with more than average ability. His father brought him back to Sydney to study medicine. He found it necessary, according to the requirements at the time, to spend one year in the Faculty of Arts—a provision which would be of benefit to most medical graduates of the present day. It was fortunate for the University of Sydney and for medicine in Australia that Craig was made to study medicine in Sydney and not in Edinburgh, for in after years he remembered the source of his learning and showed his appreciation and affection for it in a practical way. He was a most successful student in the medical course; he gained an honours pass in his first year and was placed first in the list of each subsequent year. During his undergraduate days he played as enthusiastically as he worked, and with the same success—he was champion long-distance runner of his time and gained his "blue" for athletics.

After graduation, Craig became resident medical officer at the Royal Prince Alfred Hospital (in those days it had not the prefix "Royal"). At this time the surgeons at the hospital included Sir Alexander MacCormick, Sir Charles Clubbe and the late Critchley Hinder. These men by precept and example did much to instil into the mind of the young graduate the enthusiasm and love for the art which he later adorned. After his year's residence Craig went into general practice in Newtown, a suburb of Sydney close to the Royal Prince Alfred Hospital. He was soon appointed Honorary Assistant Surgeon, and put his foot on the first rung of the ladder to success. Energy, keenness and a determination to know marked all his work, not only at this stage, but later. He was impressed by the cystoscope and what it revealed in the hands of Critchley Hinder. At first he gave himself up to general surgery and, while he was not spectacular, he established a reputation for reliability and soundness of judgement. He was a good teacher, clear in diction and patient in bearing. He had an understanding and sympathetic mind which was brought to the service of the patient and the patient's problems. In due course the appointment as "full" surgeon came, but Craig always hankered after a life specially devoted to the practice of urology. He realized his ambition. The Department of Urology at the Royal Prince Alfred Hospital was founded by him; he endowed it with the sum of £20,000. His object was twofold. He wished to make provision for the training of young graduates as urologists, and he sought to combine this training with research. The Gordon Craig Foundation

has justified its existence. Not only have several Fellows in Urology been trained, but important investigations have been made by members of the staff. Craig's urological work received recognition in other parts of the world. He was a member of the editorial committee of *The British Journal of Urology*, and he was made an honorary Fellow of the American College of Surgeons. His contributions to medical literature on urological subjects, while not numerous, were marked by sincerity and a desire to further knowledge. He was Honorary Urologist to the Royal Alexandra Hospital for Children, Sydney.

Of the part taken by Craig in the formation and development of the Royal Australasian College of Surgeons (or as it was originally, the College of Surgeons of Australasia) it is difficult to write. To state baldly that he was one of the Founders, that he was a member of the Council, that he was a member of the Credentials Committee of the State of New South Wales, is to state what everyone interested in the College knows. He was much more. He was a tower of strength. Only those who laboured with him in the early days of the College know how much the College owes to his discrimination, his foresight and his determination. He wished to see the College not only representative of the best surgical practice in Australia and New Zealand, but he wished to see it set a standard in surgical training and research. He has given evidence of his desires in his bequest to the College. The residue of his trust estate, amounting approximately to £40,000, has been left upon trust to the College "subject to such conditions as shall be determined by the Governing Body for the time being of such College." Owing to the necessity of paying certain annuities, the College will not benefit immediately from the bequest. Gordon Craig wished that one-half of the endowment should be devoted to the promotion of surgical research and that the other should be used for the training of young surgeons who show evidence of ability.

In other spheres Craig distinguished himself and gave useful service. During the war he had command of the Hospital Ship *Karoola* and took great pride in its equipment which he superintended. He took an active part in the affairs of the British Medical Association. He was President of the New South Wales Branch in 1917-1918, he was for many years a member of the Branch Council. He was President of the Section of Surgery of the First Session of the Australasian Medical Congress (British Medical Association). Those who were privileged to know him in private life all bear witness to his upright character and to the unalloyed happiness of his married life.

At the meeting of the Council of the College held in October last, the following resolution was adopted on the motion of the President, Sir Henry Newland:

> That this Council of the Royal Australasian College of Surgeons wishes to place on record its very deep sorrow for the death of Robert Gordon Craig, who was one of the Founders of the College and who, besides assisting greatly in its development, aided the advance of the Science of Surgery not only by his own valuable work, but also by his endowment of Surgical Research. His death is a most serious loss to the College and to the public at large. The Council offers to Mrs. Craig and her daughters its deepest sympathy and its most grateful appreciation of his great services.

All Fellows of the Royal Australasian College of Surgeons will wish to associate themselves with this expression of appreciation and sympathy. Gordon Craig set an example in life and character for emulation by others.